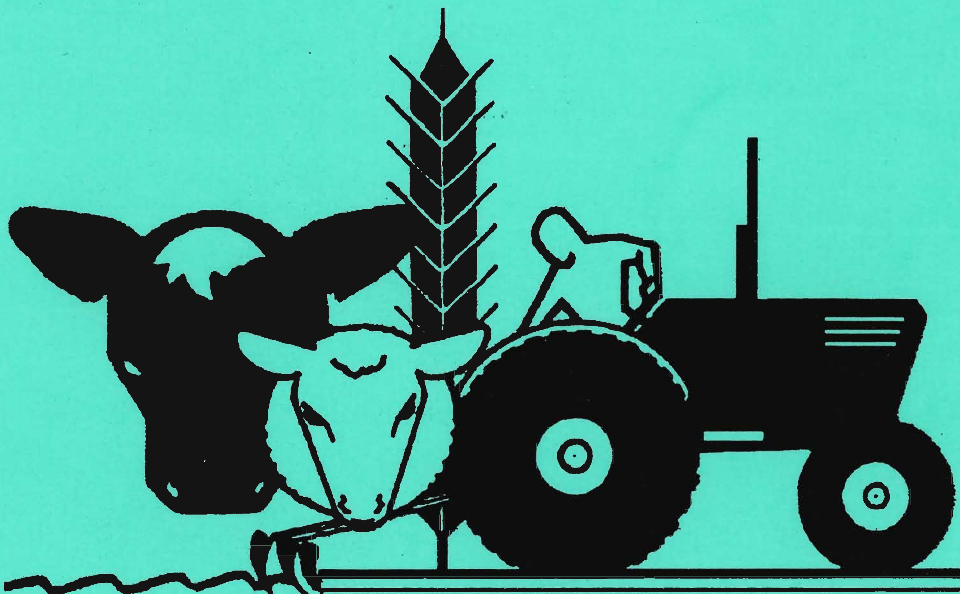
FARM TECHNICAL MANUAL



Farm Management Department
Lincoln University

FARM

TECHNICAL

MANUAL

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PREFACE

The ***Farm Technical Manual*** is a versatile reference book which brings into one place all manner of essential technical information required by farmers and others involved in the farming industry. The Manual has been designed with the practitioner in mind, providing data gleaned from many sources, but presented in non-technical language wherever possible.

Last produced in 1986, the Technical Manual was much in need of up-dating. This has been done and, at the same time, all sections have been extensively revised and improved, with some being completely re-written.

We would like to thank all individuals and organisations who have provided information for our use. Without their assistance, the production of this manual would not be feasible. We wish to express our special appreciation to Mr G.J. Walton, B.Agr.Sc, for the major contribution he made in the preparation of the manuscript and technical tables.

Please note that each of the seven sections is paged individually, for example, page A-90 refers to the 90th page of the first section; B-40 refers to the 40th page of the second section.

While every effort has been made to ensure that the information in this publication is accurate, Lincoln University cannot accept responsibility for any errors or omissions or for any loss or damage resulting from the reliance on or the use of information contained in this Manual.

Trade names, by necessity, have been included on occasion through the Manual, but no preferential endorsement by the University is intended nor is criticism implied if a particular product or trade name does not appear.

Any suggestions for the improvement of the Manual would be welcomed.

For readers' information, the Farm Management Department also produces a companion volume - the "Financial Budget Manual", which is an essential budgeting aid for farmers and growers, and is produced in March of each year.

P.H. Fleming, E.S. Burtt,
Editors January 1991.

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SECTION 1

LIVESTOCK AND FEED

1.1 LIVESTOCK FEED REQUIREMENTS AND LIVEWEIGHT CHARTS

(Compiled by P.H. Fleming, Farm Management Department.)

1.1.1 Introduction

"Dry Matter":

For the sake of convenience, feed requirements have been expressed in terms of kilograms of Dry Matter (kg D.M. - see *Note 1.* below) rather than in Megajoules of Metabolisable Energy (MJME - see *Note 2.* below).

Converting the kg D.M. figures to MJME is simply done by multiplying by the ME content of the feed - refer to "Farm Conditions" below.

Note 1: "Dry Matter" is a standardised measure of feed quantity: it is the weight of feed after all the moisture has been extracted from it. The Dry Matter contents of various feeds can be seen in Section 1.11.1; for example dry stalky ryegrass pasture has a D.M. content of 28% , or, put another way, it has a moisture content of 72%.

Note 2: "Metabolisable Energy" is a good measure of the nutritive value of feed - M.E. is the proportion of feed energy absorbed from the digestive tract and retained for metabolic purposes[1]. All feeds can be ranked on their metabolisable energy content as a proportion of feed dry matter (M/D value, expressed as MJME/kg D.M.) to indicate their value to ruminants. The M/D value of a feed may be called the "M.E. Concentration" of that feed; refer to Section 1.11.1. For example, dry stalky ryegrass pasture has a M.E. concentration of 8.0.

Farm Conditions:

Throughout Section 1.1, the assumption is made that stock are grazed on mixed length, leafy, ryegrass/white clover pasture, which has a Metabolisable Energy Concentration of approximately 11.0 MJME per kg D.M. Hence, if the requirement for an animal is shown as say, 1.0 kg D.M. per day, this figure can be converted into MJME by multiplying by 11.0. That is, the animal requires 11.0 MJME per day. If stock are to be fed on higher quality feed, such as short, leafy, spring pasture with a M.E. concentration of 11.8 (see Section 1.11.1), they will require less feed than that shown (11.0 ÷ 11.8 x 100 = 93 %; that is 7 % less D.M. required). If however, the feed is of lower quality, such as "autumn saved" pasture (fed in winter) with a M.E. concentration of 10.0, they will require more feed than shown (11.0 ÷ 10.0 x 100 = 110 %; that is 10 % more D.M. required).

The assumption is also made that in estimating normal energy requirements for grazing, walking etc., stock are grazed on 'good' hill country. Feed requirements will be more than those shown, if the stock are run in difficult or very difficult conditions (e.g. on harder hill country, or if pasture is sparse and water is some distance away, or if climatic conditions are harsh). In these conditions, 10% to 20% more feed may be required.

For stock being run in very favourable conditions, 10% to 15% less feed may be required e.g. on flat land, and/or where pasture is plentiful and stock can obtain their feed requirements with only a few hours grazing per day. *Note that it is assumed that dairy cattle are only run on easier terrain; no adjustment is required in their case.*

References:

Information from a number of sources has been adapted and condensed to create this section on "Livestock Feed Requirements". It has been designed for use by farmers and other practitioners. Further and more detailed information can be found in a number of useful texts, including:

1. "Livestock Feeding on Pasture", N.Z.S.A.P. (1987), Occasional Publication No. 10.*

2. "Supplementary Feeding" N.Z.S.A.P. (1980), Occasional Publication No. 7.*

3. "Milk Production from Pasture" Holmes and Wilson (1984).*

4. Various M.A.F. "Aglinks" on stock nutrition.

5. Pork Industry Board 'Pigfax' publications.

6. "Sheep and Cattle Nutrition" M.A.F. Agricultural Research Division (1979).

7. "Feed Budgeting" M.A.F. Advisory Services Division (1976).

* *Available from Lincoln University Bookshop.*

1.1.2 Breeding Ewe (and lamb) Feed Requirements *and Liveweight Chart*
(See also Section 1.1.1)

(1) Weaned Ewes in Summer:

a) ***Maintenance**** requirements (adult, non-pregnant sheep):

Ewe liveweight	Dry Matter Requirements	
45 kg	0.80 to 0.85 kg DM	per head/day
55 kg	0.90 to 1.00 kg DM	
65 kg	1.05 to 1.15 kg DM	

* *"maintenance" implies that the sheep are neither losing nor gaining bodyweight.*

b) Feed Requirements to ***Increase Liveweight***

Initial	Liveweight Gain (grams/day**):		
Liveweight	50g	100g	150g
45 kg	1.10 kgDM/day	1.35 kgDM/day	1.65 kgDM/day
55 kg	1.25 "	1.55 "	1.90 "
65 kg	1.30 "	1.65 "	2.10 "

** *A liveweight gain of 50 g/day equates to approximately 1 kg gain in 3 weeks; 100 g/day equates to 1 kg gain in 10 days; 150 g/day (maximum likely growth) equates to 1 kg in 1 week.*

In general, mature ewes require an extra (over maintenance) 5.5 to 7.3 kg of dry matter to put on 1 kg of liveweight. If however ewes have been losing weight, and are then put onto good feed, they will initially require only 2.7 to 3.6 kg of DM to put on 1 kg of liveweight, because of the high water content in regained tissue.

c) ***Liveweight Loss***
In a liveweight loss situation, feed requirements would be reduced by 0.15 kg DM for each 100 grams of weight lost per day.

(2) Feeding Ewes for Tupping:
Tables 1 (a) and (b) above provide the basic information required. Some sources advocate feeding ewes at up to 1.5 times their normal maintenance ration during 'flushing'. Based on this, ewes would require approximately: (see over page)

Initial Ewe Liveweight	Kg D.M./head/day
45 kg	1.20 to 1.28
55 kg	1.35 to 1.73

(3) Early to Mid Winter (2 to 3 months before lambing):

Ewe Liveweight	3 Months Before Lambing	2 Months Before Lambing
45 kg	0.85-0.90 kgDM/day	0.90-0.95 kgDM/day
55 kg	0.95-1.05 "	1.00-1.10 "
65 kg	1.10-1.20 "	1.15-1.25 "

(4) Late Winter/Pre-Lamb/Start of Lambing:

Ewe Liveweight	1 Month Before Lambing	2 Weeks Before Lambing	Onset of Lambing
45 kg	1.05 - 1.10 kgDM/day	1.15 - 1.20 kgDM	1.30 - 1.35 kgDM
55 kg	1.15 - 1.25 "	1.25 - 1.35 "	1.40 - 1.50 "
65 kg	1.30 - 1.40 "	1.40 - 1.50 "	1.55 - 1.65 "

Twin-bearing ewes require more feed than those carrying singles, particularly in the final weeks before lambing, i.e. up to 20 to 25% more feed than shown above. However ewes at the end of pregnancy are seldom able to eat sufficient feed to meet their total requirements, especially if they are carrying twins or are overfat. *(It follows then, that the feed provided should be of high quality.)*

Some sources simply recommend that ewes in the last month of pregnancy, should be fed at up to 1.5 times their normal maintenance ration, as for flushing - see (2) on page A-5.

See over page for further tables.

(5) Feed Requirements After Lamb Drop:

Figures are kg D.M. per head per day

Ewe Liveweight	Weeks After Lamb Drop First Week	Third Week	Sixth Week	Ninth Week
45 kg -with single lamb	1.60-1.90	1.90-2.20	1.80-2.20	1.60-1.90
55 kg -with single lamb	1.80-2.25	2.30-2.60	2.00-2.40	1.80-2.10
-with twins	2.35-2.65	2.70-3.00	2.50-3.00	1.95-2.25
65 kg -with single lamb	1.90-2.45	2.50-2.80	2.20-2.50	1.90-2.20
-with twins	2.50-2.80	2.90-3.20	2.70-3.20	2.05-2.35
Plus grass eaten by lamb or (lambs)	-	0.25 (0.35)	0.50 (0.80)	0.80 (1.45)

Some sources simply recommend feeding lactating ewes at up to 3 times their 'normal' maintenance ration.

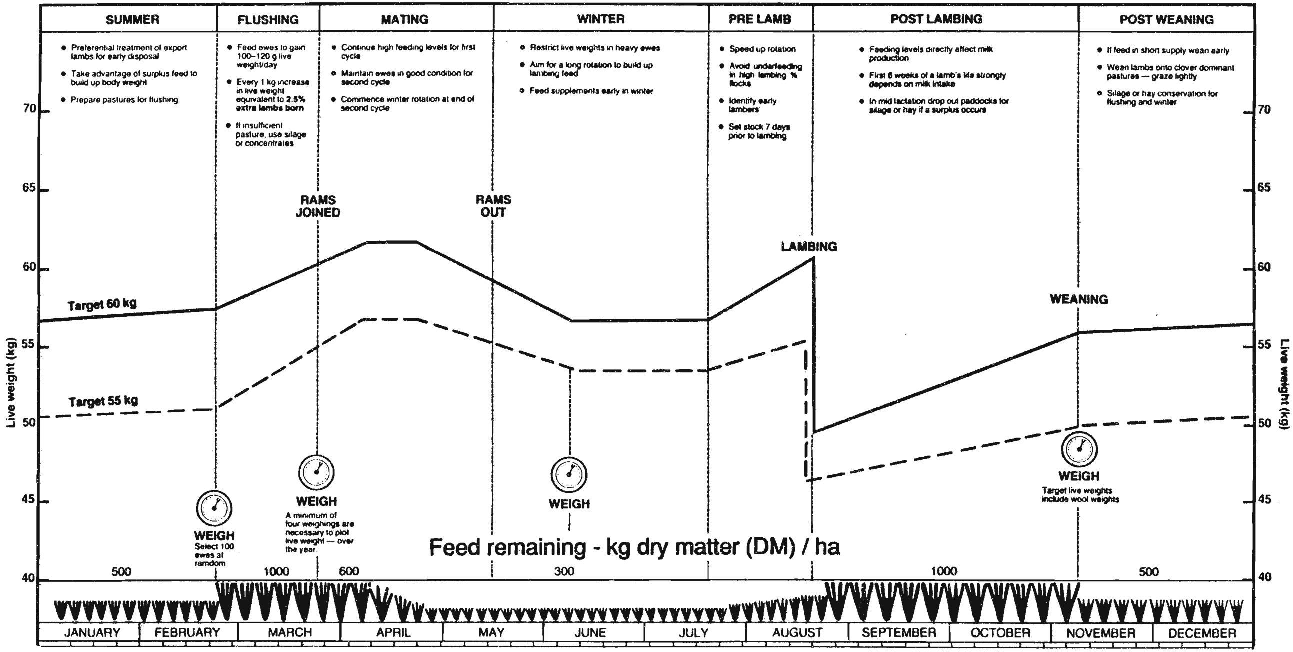
(6) Feeding Ewes After Shearing:

Feed requirements after shearing are said to increase by approximately 10 to 20% in the summer and 50 to 70% in the winter, for a period of 1 to 3 weeks, depending on the feed supply and weather conditions. Based on this, adult sheep would require approximately:

Sheep Liveweight	Feed Requirements After Shearing in: Summer	Winter
45 kg	0.90-1.00 kgD.M./day	1.20-1.45 kgD.M./day
55 kg	1.00-1.20 "	1.35-1.70 "
65 kg	1.15-1.40 "	1.55-1.95 "

(7) Ewe Liveweight Chart *and Management*

Chart produced by M.A.F. Information (Canterbury). Full scale wall charts are available from M.A.F. Agricultural Consultants, or from the Lincoln University Bookshop.



1.1.3 Lamb/Hogget Feed Requirements

(See also Section 1.1.1)

Feed requirements depend mainly on three factors; liveweight, rate of liveweight gain, and the sex of the animal.

Tables 1 and 2 below show estimated feed requirements for ram/wether lambs, and ewe lambs/hoggets:

Table 1: Feed Requirements of Ram and Wether Lambs:

Figures are kg D.M. per head per day

Initial Liveweight	Growth Rate/Liveweight Gain* (grams per day): Nil Gain	100 g	150 g	200 g	300 g
20 kg	0.55-0.60 kgDM	0.85 kgDM	1.00 kgDM	1.15 kgDM	1.40 kgDM
30 kg	0.75-0.80 kgDM	1.20 kgDM	1.35 kgDM	1.55 kgDM	1.90 kgDM
40 kg	0.95-1.00 kgDM	1.45 kgDM	1.70 kgDM	1.90 kgDM	2.35 kgDM

* *Growth Rate/Liveweight Gain: Note (1) below is included to assist readers to estimate likely growth figures for male lambs at different stages:*

Note (1): 20 kg weaned male lambs (Nov. / Dec.) would need to grow at about 110 to 130 grams per day through summer/autumn to achieve a 13.5 kg carcase (30-32 kg liveweight) by mid-March, or a 15.0 kg carcase (33 to 35 kg liveweight) by mid-April.

In general, male lambs (20 kg) require an extra (over maintenance) 3 kg of dry matter to put on 1 kg of liveweight. Heavier male hoggets (40 kg) require an extra 4.5 kg of dry matter to put on 1 kg.

Table 2: Feed Requirements of Ewe Lambs / Hoggets:

Figures are kg D.M. per head per day

Initial Liveweight	Growth Rate/Liveweight Gain** (grams per day): Nil Gain	50 g	100 g	150 g	200 g
20 kg	0.60 kgDM	0.75 kgDM	0.90 kgDM	1.15 kgDM	1.30 kgDM
30 kg	0.80 kgDM	1.05 kgDM	1.25 kgDM	1.55 kgDM	1.75 kgDM
40 kg	1.00 kgDM	1.25 kgDM	1.60 kgDM	1.90 kgDM	2.25 kgDM

** *Growth Rate/Liveweight Gain: Note (2) over page is included to assist readers to estimate likely growth figures for ewe lambs at different stages:*

Note (2): 18 to 20 kg weaned ewe lambs (Nov. / Dec.) would need to grow at about 100 to 120 grams per day through summer/autumn to achieve 35 kg liveweight by mid-May; at least 40 grams per day through winter to achieve 40 kg by mid-September; and about 110 to 130 grams per day through spring/early summer to achieve 52 kg by mid January (as 2th).

In general, ewe lambs (20 to 25 kg) require an extra (over maintenance) 4 kg of dry matter to put on 1 kg of liveweight. Heavier ewe hoggets (45 kg) require an extra 6.5 kg of dry matter to put on 1 kg (similar to mature ewes).

See *page A-7* for feed requirements *after shearing.*

1.1.4 Beef Breeding Cow (and Calf) Feed Requirements *and Liveweight Chart*
(See also Section 1.1.1)

(1) Cows after weaning, in late autumn:

a) ***Maintenance Requirements:*** (mature cows)

Cow Liveweight	Dry Matter Requirements*
350 kg	4.0-4.5 kg D.M. per head/day
450 kg	4.8-5.3 kg "
550 kg	5.5-6.0 kg "

* *Requirements should be increased by approximately 15% for lean cows and reduced by 15 % for fat cows.*

b) ***Liveweight Loss:***
In a liveweight loss situation, feed requirements would be reduced by approximately 2.5 kg DM for each kilogram of weight lost.

c) ***Liveweight Gain:***
Liveweight Gain - In general, mature cows of medium breed size require an extra (over maintenance and maternal requirements) 6.5 kg of Dry Matter to put on 1 kg of liveweight. Smaller breeds may require more feed, and larger breeds less feed, to achieve the same increase in liveweight. See Section 1.1.5.

(2) Early to Mid-Winter (Maintenance Requirements):

Initial Cow Liveweight	3 Months Before Calving	2 Months Before Calving
350 kg	up to 4.7 kgDM/day	4.8-5.2 kgDM/day
450 kg	up to 5.5 kgDM/day	5.7-6.2 kgDM/day
550 kg	up to 6.3 kgDM/day	up to 6.8 kgDM/day

(3) Late Winter (pre-calving/start of calving):

Cow Liveweight	Final Month Before Calving	Onset of Calving
350 kg	5.9 - 6.2 kgDM/day	Insufficient information available. Some sources recommend similar feeding levels to those required during lactation – see (4) below.
450 kg	6.4 - 7.0 kgDM/day	
550 kg	7.5 - 7.8 kgDM/day	

(4) Feed Requirements after Calf Drop, and through the Breeding Season:
Assuming no weight gain or loss. See 1 (c), page A-10, for liveweight gain.

Figures are kg D.M. per head per day

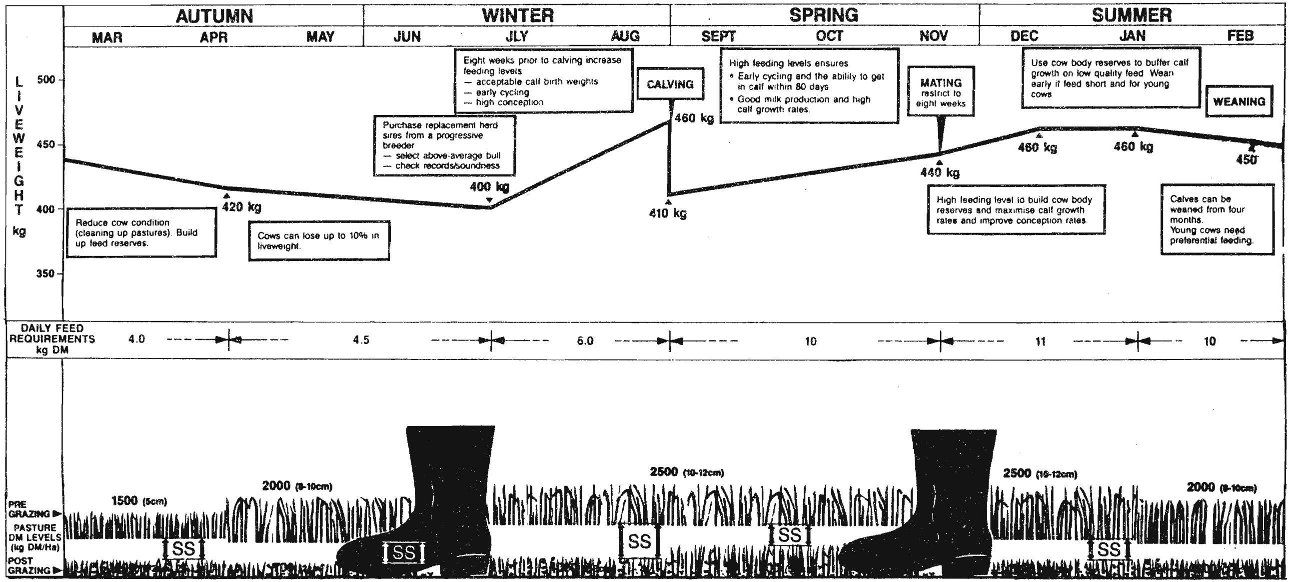
Cow Liveweight[a]	First Month of Lactation	Third Month	Fifth Month
350 kg	6.7-6.9 kg	at least 7.3 kg	6.9 kg
400 kg	about 7.5 kg[b]	at least 7.7 kg[c]	7.4 kg[e]
450 kg	7.7-7.9 kg	at least 8.3 kg[c]	8.0 kg[e]
500 kg	8.2-8.4 kg	at least 8.7 kg[d]	8.4 kg[e]
(Plus grass eaten by calf)	Nil	(plus 0.9 kg)	(plus 2.7 kg)

a. Note different liveweights compared with previous tables.
b. Some sources up to 9.0 kg
c. Some sources up to 10.5 kg
d. Some sources up to 11.0 kg
e. Some sources up to 12.0 kg

(5) Beef Breeding Cow (Mature) Liveweight Chart *and Management*

See also page A-15, "Liveweight Targets for Heifers."
Chart produced by the N.Z. Beef Council. Enquires about full scale wall charts should be addressed to Mr P. Packard, N.Z. Beef Council, C/- M.A.F., Private Bag, Auckland.

The chart shows liveweight targets for mature beef breeding cows. Liveweights and feed requirements will differ according to the type of farm and breed of cattle. The pasture grazing levels apply regardless of cow size. PRE and POST GRAZING pasture levels indicated are for rotational grazing systems. Set stocking is indicated by SS.



1.1.5 Beef - Heifer/Steer/Bull - Feed Requirements *and Liveweight Charts*
(See also Section 1.1.1)

Feed requirements depend mainly on four factors - liveweight, breed size, rate of liveweight gain and sex of the animal.

Table 3 below shows estimated feed requirements for ***Steers***, of ***Medium Breed Size***.

Note:- for ***Heifers*** add 5% to these figures.
- for ***Bulls*** deduct 5 %.

- for ***Small Breeds***, add 5% to 10%.
- for ***Large Breeds***, deduct 4% to 8%.

Table 3: **Daily Feed Requirements* of Young/Growing Beef Cattle**

Figures are in kg D.M. per head per day.

Initial Liveweight	Growth Rate/Liveweight Gain** (kilograms per day): 0	0.25	0.50	0.75	1.0	1.25	1.50
100 kg	2.0	2.4	2.8	3.2	3.7	4.1	4.6
150 kg	2.5	3.0	3.6	4.2	4.8	5.3	5.9
200 kg	3.0	3.7	4.4	5.1	5.8	6.5	7.2
250 kg	3.5	4.3	5.1	5.9	6.7	7.6	8.5
300 kg	4.0	4.9	5.8	6.7	7.7	8.7	9.7
350 kg	4.4	5.5	6.5	7.5	8.6	9.7	10.8
400 kg	4.8	6.0	7.1	8.3	9.5	10.7	11.9
450 kg	5.3	6.5	7.8	9.1	10.4	11.7	13.0
500 kg	5.7	7.0	8.4	9.8	11.2	12.6	14.0

* *Daily Feed Requirements: In reality these requirements may differ by 10% to 20 % depending on the climate, contour of farm, and ease of grazing (Section 1.1.1).*

** *Growth Rate/Liveweight Gain: Notes 1. and 2. (below and over page), are included to assist readers to estimate likely growth figures for different classes of young stock. Liveweight charts are also shown in Figures 1 and 2, pages A-15 and A-16.*

Note 1: For beef weaners of medium breed size, growth rate targets (see over page) would be similar for both steers and heifers in the following situations:
- taking steers through to about 340 kg liveweight (180 kg c.w.) by 18 to 20 months.
- taking heifers through to about 250 kg liveweight for mating as yearlings, and through to about 350 to 370 kg liveweight by early winter.

Growth Rate Targets:
Starting in autumn, the 160 to 180 kg weaned calves would need to grow at about 0.25 to 0.4 kg per day through autumn/winter to achieve 200 kg liveweight by early August; about 0.6 to 1.0 kg per day through spring/early summer to achieve at least 250 kg by early November; and about 0.5 to 0.6 kg per day through summer/autumn to achieve the 350 to 370 kg liveweight target by early winter (see also Beef Calf/Weaner Growth Rates, below).

Note 2: For 'Dairy Beef' weaner bull calves:
Calves weighing about 90 to 100kg (at 3 to 4 months) would need to grow at about 0.5 to 0.9 kg per day through summer/autumn to achieve 240 to 250 kg liveweight by June; 0.4 to 0.5 kg per day through winter to achieve 280 to 300 kg by the end of August; 1.0 to 1.5 kg per day through spring to achieve 400 kg (210 kg c.w.) by the end of November, and 0.5 to 0.7 kg per day through summer/autumn to achieve 450 kg (235 kg c.w.) by end February or 500 kg (260 kg c.w.) by end May.

Beef Calf/Weaner Growth Rates:
(Source: Animal Science Department, 1986.)

Growth rate is affected by the quality and quantity of feed available and by the breed or cross of the animal. Weight gains can vary greatly depending on the system of production, but calves single suckling beef cows generally gain from 0.5 to 1.0 kg/day.
The average figures for cattle post-weaning are: (kg L.W. gain per day)

Autumn	Winter	Spring	Summer
0.5	0.0 - 0.6	1.0 - 1.2	0.6 - 0.8

Figure 1: Beef Heifer Liveweight Chart *and Management*

See also page A-12, "Liveweight Targets for Mature Breeding Cows".
Chart produced by the N.Z. Beef Council. Enquires about full scale wall charts should be addressed to Mr P. Packard, N.Z. Beef Council, C/- M.A.F., Private Bag, Auckland.

The chart shows liveweight targets for the successful mating and rebreeding of yearling beef heifers (medium breed size). Liveweights and feed requirements will differ according to the type of farm and breed of cattle. The pasture grazing levels apply regardless of heifer size. PRE and POST GRAZING pasture levels indicated are for rotational grazing systems. Set stocking is indicated by SS.

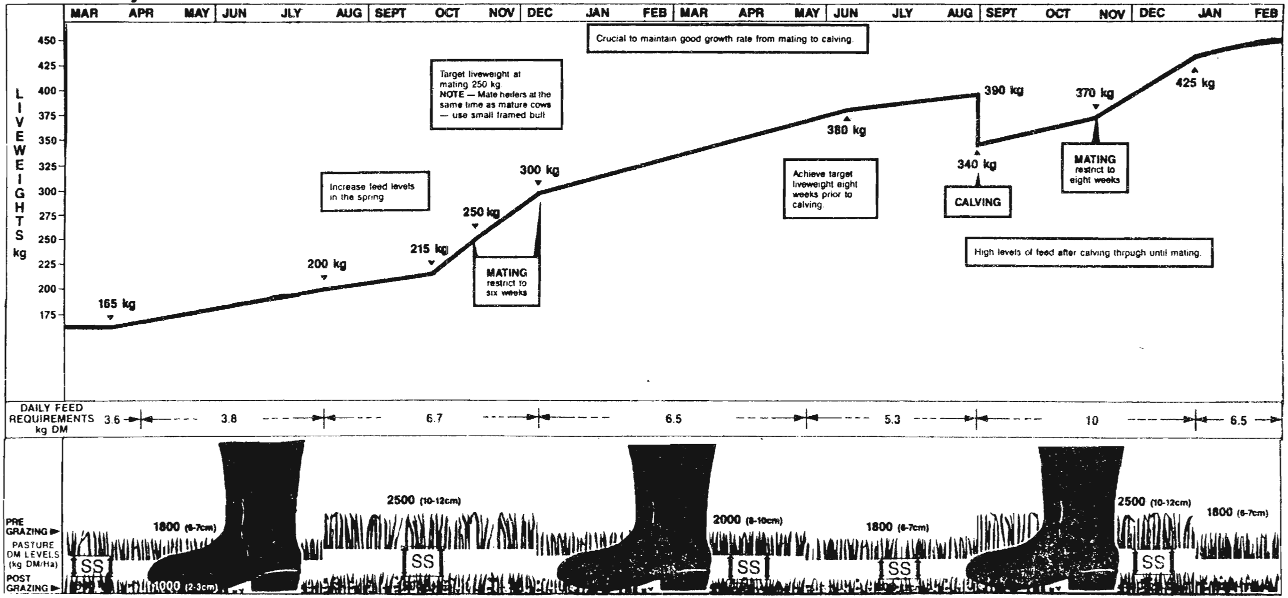
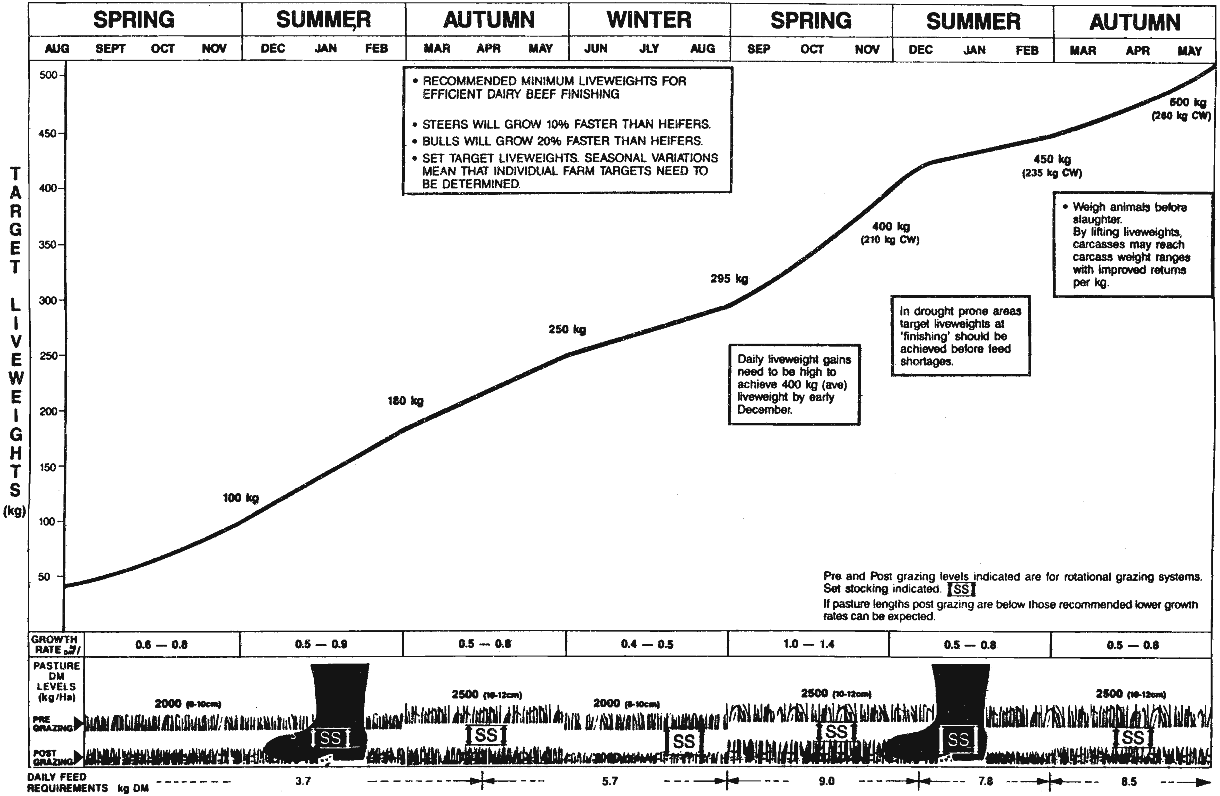


Figure 2: Dairy Beef Liveweight Chart ***and Management (Source: N.Z. Beef Council. See page A-15 for details).***



1.1.6 Dairy Cow Feed Requirements

(Note: Assuming good quality pasture and easy farm contour - see also Section 1.1.1)

(1) Feed Requirements for Dry Cows in Winter:

a) ***Dry Cows in Adequate Condition*** (no increase in condition score required):

figures are kg D.M. per head per day

Months Before Calving:

Initial Cow Liveweight[z]	3 Months Before	2 Months Before	Final Month
(Jersey) 350 kg (Friesian) 450 kg	3.5 - 4.0[x] 4.5 - 5.0[y]	at least 4.0 at least 5.0	5.5 - 6.0 7.0 - 8.0

x: *some sources up to 5 kg D.M./day*
y: *some sources up to 6 kg D.M./day*
z: *Cow liveweight - the feeding levels shown provide for normal increases in liveweight due to pregnancy - see target weights below:*

Target liveweights for dairy cows immediately before calving are as follows: (Source: T.P. Hughes, Animal Science Department, 1986)

Age of Cow	Jersey	Friesian
2 yrs	320 kg L.W.	410 kg L.W.
3 yrs	380 kg	460 kg
4 +	420 kg	540 kg
Herd average	385 kg	470 kg

Note : Target liveweights for heifers (from weaning) can be seen on page A-19.

b) ***Dry Cows in Poor Condition:***

For cow condition score to improve by 1 (say, from C.S. 4 to 5 - *see Section 1.7*), "true" body-weight must increase by 25 to 35 kg (over and above the increases associated with pregnancy).
In the *average* situation, 60 to 70 days of increased feeding (approximately 2.5 to 3.0 kg D.M. extra per day) would be required to put on this weight.

Maximum possible gain in cow "condition" in early winter is about 1.0 kg liveweight per day; and in late pregnancy is about 0.5 kg liveweight/day. From this it can be seen that the best time to improve cow condition is in autumn/early winter.

In general, for mature cows, an extra 6.0 to 6.5 kg of pasture dry matter is required for every 1.0 kg gain in liveweight.

(2) Feed Requirements for Cows in Milk:

a) ***Feed Requirements according to Level of Production:***
figures are kg D.M. per head per day

Cow Liveweight	Level of Milkfat Production per Day: 1.0 kg M.F. (about 18-25 litres milk)	0.8 kg M.F. (about 15-20 litres milk)	0.6 kg M.F. (about 11-15 litres milk)	0.4 kg M.F. (about 7-10 litres milk)
(Jersey) 350 kg	14.5* kg DM	12-13 kg DM	10-11 kg DM	8-9 kg DM
(Friesian) 450 kg	16.5* kg DM	14-15 kg DM	12-13 kg DM	10-11 kg DM

** Some sources recommend more feed (than shown) after calving. However, in early lactation, it is common for cows to lose approximately 0.5 kg liveweight per day, and to consume even less feed than that shown (1.0 to 1.5 kg D.M. less per day) while maintaining high milkfat production. These liveweight losses (immediately after calving) may occur regardless of the level of feeding offered to the cow. See also **(b)** below.*

b) ***Liveweight Gain or Loss*** (During the Milking Season):
(See also * above)
An additional 2.5 to 3.0 kg D.M./day would be required to gain 1 condition score (about 30 kg liveweight) over a period of 60 to 70 days. This represents a very high level of feeding.
Younger cows, in the process of "growing out" to their mature body-size, will require additional feeding though the season to account for the increase in liveweight. Also it takes more feed to increase the condition score of heifers than it does in older cows.

1.1.7 Dairy Heifer Feed Requirements *and Liveweight Chart*

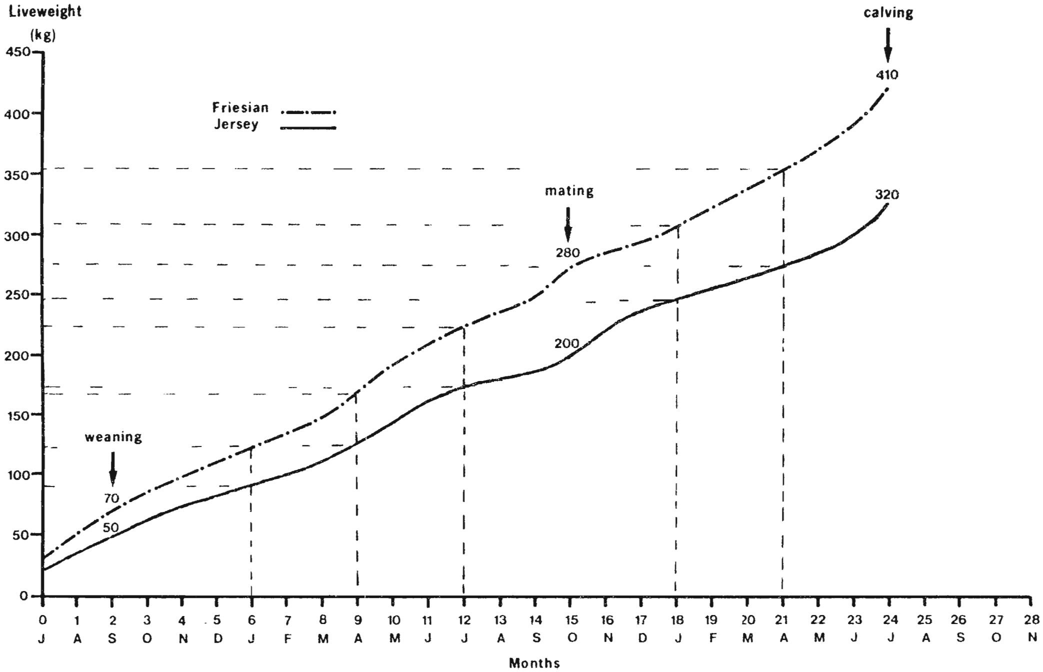
Note: Assumes good quality pasture and easy farm contour - see also Section 1.1.1.
To reach the liveweight targets as shown in Figure 3, page A-19, the approximate feed requirements for heifer calves/yearlings are as follows:

	kgD.M. per head per day**	
Time of year	Jersey	Friesian
First summer/autumn (5-8 mths old)	2.5-3.5	3.0-4.0
Winter/early spring	3.0-4.0	4.0-5.0
Late spring/summer (15-17 mths old)	4.0-5.0	5.0-6.0
Second autumn/winter	4.5-6.0	6.0-7.0

** *Feed calculations are for Jerseys growing at 0.3 to 0.5 kg liveweight gain per day, and Friesians growing at 0.35 to 0.65 kg/day (varies according to season and age of heifer).*

Figure 3: Liveweight Chart for Dairy Heifers (Source: N.Z. Dairy Board)

The target liveweights shown are recommended <u>minimums</u>.



1.1.8 Red Deer Feed Requirements
(See also Section 1.1.1)

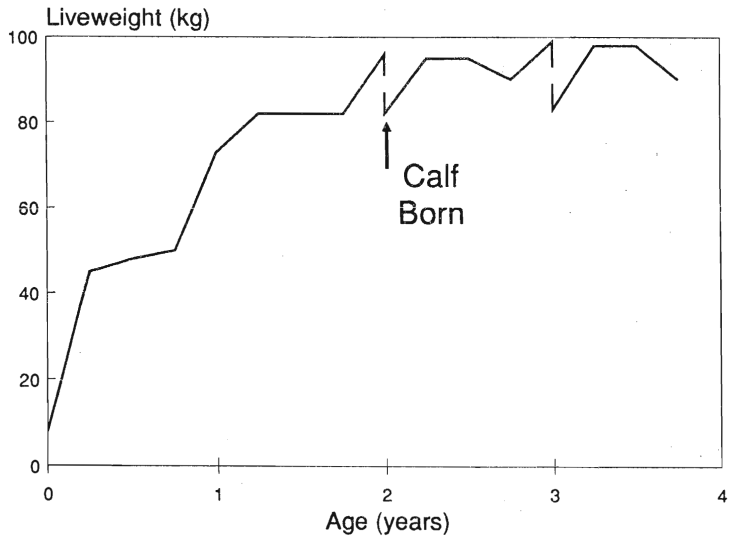
Information derived from "Livestock Feeding on Pasture", NZSAP (1987), Occasional Publication No. 10.

(1) Feed requirements for Red Deer hinds, following a liveweight pattern similar to that shown in Figure 4.

kg of D.M. per head per day:

Age	Summer	Autumn	Winter	Spring
1 to 12 months	*suckling*	1.4	1.6	2.0
13 to 24 months	1.9	1.9	2.1	2.1 *(in calf)*
25 months and older	4.1-4.3 *(lactating)*	2.1	2.0-2.2	2.2 *(in calf)*

Figure 4: **Liveweight Pattern of Hinds (Red Deer):**
(Source: M.A.F.)



(2) Feed Requirements for Red Deer stags, following a liveweight pattern similar to that shown in Figure 5.

***kg of D.M. per head per day*:**

Age	Summer	Autumn	Winter	Spring
1 to 12 months	*suckling*	1.5	1.9	2.5
13 to 24 months	2.4	2.2	2.5	2.8
25 to 36 months	2.7	2.1	3.0	3.4
37 months and older	3.4-3.5	1.7	3.0-3.3	3.5-4.0

Figure 5: **Liveweight Pattern of Stags (Red Deer):**
(Source: M.A.F.)

1.1.9 Goat Feed Requirements
(See also Section 1.1.1)

Limited information is available on the pastoral feed requirements of goats. The following estimates are derived from information contained in "Livestock Feeding on Pasture", NZSAP (1987), Occasional Publication No. 10.

(1) Maintenance* Requirements:

Goat Liveweight:	20 kg	30 kg	40 kg	50 kg	60 kg
Feed Requirements: (kg D.M./head/day)	0.50	0.67	0.84	1.00	1.15

* *Feed requirements will be about 10% higher in steep/difficult grazing conditions, and 10% lower where grazing conditions are easy/plentiful.*

(2) Feed Requirements to *Increase* Liveweight:
In general, goats require an extra 2.5 to 3.0 kg of dry matter (over maintenance) to put on 1 kg of liveweight.

(3) Doe Requirements in Late Pregnancy:
In general, does require an extra 0.5 to 0.6 kg of dry matter *per day*, (over maintenance) in the final two months pregnancy.

(4) Feed Requirements for Lactation:
In early lactation, does require an *additional* 0.7 to 1.4 kg of dry matter per day (over maintenance), depending on milk volume produced. In late lactation, *additional* feed requirements reduce to 0.2 to 0.5 kg D.M./day.

1.1.10 Pig Nutrition
Note 1: See also Section 1.11.2, Nutritive Value of Pig Feeds.
Note 2: Parts of Section 1.1.1 (Introduction) do not apply to this section.

Maize and barley provide the major source of energy in pig rations in New Zealand. These and other cereals, while being concentrated sources of digestible energy (DE), are inadequate in terms of protein quantity and quality for both the young growing pig and the adult sow in late pregnancy and lactation. Protein quality is assessed in terms of the amounts of specific amino acids (the constituents of protein) that a particular food provides relative to that required by the pig. Proteins are made up of different combinations of individual amino acids linked together in chains. The greatest requirement for amino acids in the animal is for deposition of lean meat and milk production. The supply of individual amino acids from the gut is unlikely to correspond to that required by the pig. In such circumstances the liver of the pig has the ability to synthesize some of the required amino acids from others supplied to excess in the diet.

However there are about 11 amino acids (termed essential amino acids) which must be provided as they can not be readily synthesized by the pigs liver. A commonly accepted list of essential amino acids would be:
lysine, methionine, cystine, threonine, phenylalanine, histidine, tryptophan, leucine, isoleucine, valine and arginine.

The way in which the protein is presented in the diet is important as large coarse feed particles may prevent complete digestion. Heating of protein decreases the proportion which can be absorbed from the gut, usually by about 5 percent. However, excessive heating may completely alter the structure of the dietary protein (denature) making it largely unavailable to the animal. Offal products from the freezing industry in New Zealand may sometimes be affected by excess processing with a subsequent drop in protein feed value.

Many of the essential vitamins and minerals are also in short supply, but these are usually adequately supplied by the inclusion of a mineral/vitamin proprietary mixture. Three exceptions are:

1. Calcium and Phosphorus - usually added in various combinations of ground limestone, steamed bone flour, dicalcium phosphate and rock phosphate.

2. Sodium and Chlorine - added in the form of common salt (0.25% of air dry diet).

3. There is field evidence that sows may benefit in certain situations from additional supplies of the vitamins A, D and E during gestation.

The above text was revised (1986) with the assistance of T.P. Hughes, Animal and Veterinary Sciences Department.

TABLE 4: Recommended Feeding Levels for Breeding Stock *(Source: N.Z. Pork Board)*

	Daily Digestible Energy Intake	Daily Crude Protein Intake	Daily Allowance of Balanced Barley-based Ration *	Daily Allowance of Balanced Maize-based Ration **
Puberty (210 days naturally or 160 days induced with mating 19 to 39 days later)	31 MJ	120-190 g	2.7 kg	2.6 kg
Prior to mating (last 2 weeks)	45 MJ	120-190 g	3.5 kg	3.0 kg
Gestation (sow 150 kg liveweight)	25 MJ	250 g	2.0 kg	1.7 kg
Lactation (sow 120 - 200 kg liveweight: 1.5 kg meal/day for sow + 0.5 kg meal/day for each piglet suckled)	75 MJ	750 g	6.0 kg	5.3 kg
Weaning to Mating Interval	43 MJ	250 g	3.5 kg	3.0 kg
Boars	35 MJ	250 g	2.7 kg	2.5 kg

* 12.75 MJ DE/kg feed.
** 14.25 MJ DE/kg feed.

Source - Pigtech:

Class of Stock	Diet Fed
Sows	Breeder
Boars	Breeder
Suckers	Creep
Weaners	Creep and weaner
Porkers	Grower
Baconers	Grower and finisher

Feeding Levels *(see next table for Nutrient Requirements)*

Class of Stock	Liveweight (kg)	Diet	Amount fed/day (kg)
Pregnant sow		Breeder	2.0 - 2.3
Lactating sow		Breeder	4.5 - 6.0
Boar		Breeder	2.5 - 2.8
Weaner	8	Creep	0.3 - 0.4
Weaner	15	Weaner	0.6 - 0.8
Weaner	20	Weaner	1.0 - 1.2
Grower	30	Grower	1.4 - 1.6
Grower	55	Grower	2.0 - 2.2
Grower	80	Grower	2.5 - 2.7

Nutrient Requirement of Pigs

Class of Stock	Creep	Weaner	Grower	Breeder
Liveweight range (kg)	3 - 10	10 - 25	25 - 85	
Energy (MJ/kg)*	13.8	13.0	12.7	12.5
Protein (%)	20 - 22	18 - 20	15 - 17	14.0
Lysine (%)	1.30	1.10	0.92	0.60
Methionine (%)	0.65	0.55	0.46	
Tryptophan (%)	0.18	0.15	0.13	
Calcium	1.0 - 1.4	1.0 - 1.4	1.0 - 1.65	1.5
Phosphorus	0.8 - 1.1	0.8 - 1.1	0.8 - 1.2	1.00

* *Energy levels are expressed in terms of Mega Joules per kilogram.*

1.2 PHYSIOLOGY OF LIVESTOCK

This Section revised with the assistance of the Animal and Veterinary Sciences Department, 1986.

1.2.1 Breeding Date Table

Time of Service	Calving Date	Lambing Date	Farrowing Date	Calving Date (Deer)
July 9	April 17	December 5	October 31	
July 23	May 1	December 19	November 14	
August 6	May 15	January 2	November 28	
August 20	May 29	January 16	December 12	
Sept 3	June 12	January 30	December 26	
Sept 17	June 26		January 9	
October 1	July 10		January 23	
October 15	July 24		February 6	
October 29	August 7		February 20	
November 12	August 21		March 6	
November 26	September 4		March 20	
December 10	September 18		April 3	
December 24	October 2	May 22	April 17	
January 8	October 17	June 6	May 2	
January 22	October 31	June 20	May 16	
February 5	November 14	July 4	May 30	
February 19	November 28	July 18	June 13	
March 5	December 12	August 1	June 27	
March 19	December 26	August 15	July 11	
April 2	January 9	August 29	July 25	November 21
April 16	January 23	September 12	August 8	December 5
April 30	February 6	September 26	August 22	December 19
May 14	February 20	October 10	September 5	January 2
May 28	March 6	October 24	September 19	January 16
June 11	March 20	November 7	October 3	January 30
June 25	April 3	November 21	October 17	February 13

1.2.2 Gestation Period (Term of Pregnancy)

	Average Period (Days)	*Range (Days)*
Mare	347	322 - 419
Cow (9 months plus 9 days)	282	272 - 292
Ewe (5 months less 5 days)	147	140 - 160
Sow (3 months, 3 weeks, 3 days)	115	109 - 143
Hind	233	223 - 243
Goat	156	150 - 163
Bitch	60	55 - 63
Cat	50	48 - 56
Rabbit	28	20 - 35
Turkey	26	24 - 30
Hen	21	19 - 24
Duck	30	28 - 32
Goose	30	27 - 33
Pigeon	18	16 - 20
Alpaca	345	

1.2.3 "Heat"/Oestrus Table

	Duration of Oestrum	*Return after Parturition*	*Recurrence if not pregnant*
Ewe- 2th - mature	8-18 hours 20-36 hours	Late summer/aut. (4 to 6 months)	17 days (12-19 days)
Cow	14 hours (10-18 hours)	40-120 days	21 days (18-24 days)
Mare	4.5-9 days	9-14 days	21 days (12-25 days)
Sow	2-3 days	7 days after weaning	21 days (14-26 days)
Bitch	4-13 days	5-6 months	
Hind	-	3-4 months	18 days

1.2.4 Age of Puberty

	Normal Time (Age in months)		Normal Time (Age in months)
Sheep	8 - 12	Cattle	12 - 18
Pig	4 - 5	Horse	12 - 24
Dog	7 - 10	Goat	8 - 12
Deer	14 - 16		

Puberty is the age at which animals are capable of breeding for the first time.
The main factor affecting puberty is body weight, which is affected by feeding level, breed and extremes of climate.

1.2.5 Determining Age of Livestock

(1) Age of Sheep

The age of sheep can be gauged approximately by the time of the appearance of permanent incisors, there being four pairs, all in the lower jaw. A more accurate method is by the use of age marks and eartags.

Incisor teeth erupt as follows:

Teeth	*Age at Eruption*	*Common Term*
First or central pair of incisors	12 to 18 months	2 tooth
Second pair of incisors	20 to 24 months	4 tooth
Third pair of incisors	26 to 30 months	6 tooth
Fourth pair of incisors	34 to 40 months	full mouth

Type of feed and pasture have a good deal of influence on the rate at which the teeth of a sheep begin to wear and fall out. The extent of teeth wear largely influences the age at which sheep are culled. Normally a ewe is culled at 6 to 7 years of age.

(2) Age of Cattle

The age of cattle is often estimated from the general appearance of the animal. However, the time that the teeth erupt can be used as a guide to age. During the first few weeks of life, four pairs of temporary incisors in the lower jaw appear. These are replaced by the same number of permanent incisors as follows:

Teeth	*Age of Eruption*
First or central pair of incisors	22 to 30 months
Second pair of incisors	27 to 41 months
Third pair of incisors	33 to 42 months
Fourth pair of incisors	42 months

As the teeth of older cattle become worn, the space between the teeth enlarges and the gum receeds. Since factors such as level of feeding and the type of feed can influence the eruption of the permanent incisors and their wear, the state of the teeth of cattle should only be used as a guide to age.

(3) Age of Horses

Location of teeth	*Ages at eruption of permanent teeth*	*"Cups" disappear from weaning surfaces of permanent teeth lower jaw*
First pair of middle incisors	2.5 years	6 years
Second pair incisors (Located at either side of "nippers")	3.5 years	7 years
Third pair of corner incisors	4.5 years	8 years

The age of older horses is more difficult to determine but, in general, the shape of the wearing surface of the teeth gradually change from oval to triangular, the forward pitch becomes more marked, and the neck of the teeth at the gums becomes narrower. At 10 years, a groove, known as Galvayne's Groove, appears on the Upper Corner Incisor. At 15 years, this groove is halfway down the tooth, and at 20 years it is the full length of the tooth. This depends on the speed of eruption.

1.2.6 <u>Temperature, Pulse, Respiration</u> (Normal and Expected Range)

	Rectal Temperature Deg. Centigrade	*Pulse (Beats/Min)*	*Respiration (Breaths/Min)*
Sheep	38.9 (37.2-40.5)	75 (60-120)	(12 - 20)
Cattle	38.6 (37.8-39.3)	70 (40-100)	30 (27 - 40)
Pig	39.3 (38.8-40.3)	(55- 86)	(8 - 18)
Horse	37.8 (37.2-38.1)	44 (23- 70)	12 (11 - 14)
Dog	38.9 (36.7-40.5)	(100-130)	18 (11 - 38)
Goat	39.3 (37.8-40.5)	90 (70-135)	19

Rectal temperature should always be taken if, for example, symptoms are being noted in order to telephone a veterinarian for advice. It is often the single most important piece of information. It should be taken in the rectum, with an ordinary clinical thermometer being left in a minute and a half, to obtain an accurate reading.

1.3 ANIMAL HEALTH AND DISEASE

1.3.1 Drench Resistance

(Source: Anthelmintic Resistance Task Force Recommendations)

Introduction

Parasite resistance to drenches is now wide-spread on New Zealand farms, particularly in sheep and goats.

Once a parasite population on a farm becomes resistant to a drench family, then, for all practical purposes, this resistance is permanent.

The build - up of resistance in the parasite population is overtaking the rate at which new products can be developed to cope with it.

However, careful management of parasite control at the individual farm level may slow down the development of resistance and preserve drench effectiveness.

United Industry Strategy:

While these recommendations are aimed specifically at the sheep and goat industries, the same principles apply to *all* livestock:

(1) Recommendations For All Farms:

a) ***Do Not use drench unnecessarily.***
Check *at least annually* that the drench being used is working, using a simple *drench check* (faecal egg count examination 7 days after drenching).

Where resistance is suspected it should be confirmed by a faecal egg count reduction test ("Drenchtest") and/or by slaughter and worm counts.

Unexplained unthriftiness should be investigated by an animal health advisor or veterinarian.

b) ***Certain farm management practices*** can reduce the number of drench treatments needed (and hence slow the development of drench resistance) by reducing exposure of young stock to parasite-contaminated pasture. Farmers should seek advice about implementing such practices.

Farmers should consult their animal health advisor regularly on drenching programmes to ensure they use no more than the optimum number of drenches relative to their farming conditions.

c) ***Use of effective dose rates***
- Ensure your drench gun receives regular maintenance.
- Check bodyweight of animals , preferably by weighing the largest.
- Select a dose volume for the heaviest animals in the group.
- Set and check the accuracy of the drench gun by delivering several doses of the drench into a measuring vessel.
- Re-check the dose delivery regularly during the drenching operation.

d) ***Stopping the spread of the resistant parasites onto properties.***

This can be achieved by drenching all animals on or before arrival at the property *with two different drench families at the same time - see (f) below on mixing drenches.* Care should be taken to avoid drenching dehydrated or stressed animals. In some cases, it may be practical to have a "Drenchtest" under-taken on the vendor's property before stock are purchased.

e) ***Anthelmintic drugs should ideally be alternated annually*** between each of the three different drench families* or between a Combination** and an Ivermectin product.

** The three drench families are:* *Benzimidazole*
Levamisole/morantel
Ivermectins

*** Combination products will contain a mixture of a benzimidazole and levamisole.*

f) ***Do Nots***

- *do not* alternate drench families (see above) within a season/year.
- *do not* treat different mobs of sheep or goats on the same property with different drench families.
- *do not* mix drenches yourself to produce combinations as these will be unstable.
- *do not* underdose.
- *do not* determine dose rates from *estimated* animal body weights - weigh them.
- *do not* use one drench type exclusively and continuously for several years.

g) ***Do s***

- *do* use separate and correct dose rates for goats.
- *do* ask your veterinarian or animal health advisor for advice.
- *do* check regularly the performance of the drench you are using.

(2) *Recommendations For Farms where Resistance to a Drench Family Has Been Clearly Established by a "Drenchtest":*

a) Discontinue the use of all drenches of that family (see 1(e) above). Do not reconsider their use without veterinary advice and re-evaluation of their effectiveness.

b) Alternate between the remaining effective drench families.

c) Test at least annually for resistance to these drench families.

1.3.2 Mineral Deficiencies in Stock

Adapted from "Fertiliser and Lime Recommendations for Pastures and Crops in New Zealand" (1984) - Cornforth, I.S. and Sinclair, A.G. (M.A.F.).

Information source:

Information has been adapted from "The Mineral Requirements of Grazing Ruminants", published by the N.Z.S.A.P. *(available from: The Secretary, N.Z.S.A.P., Ruakura Agricultural Research Centre, Hamilton).* Readers are advised to consult the booklet first hand for a more complete account of the prevention, diagnosis and treatment of mineral deficiencies in stock.

Common Deficiencies :

The most commonly occurring major nutrient deficiency in livestock in New Zealand is magnesium (Mg). The most common trace element deficiencies are copper (Cu), cobalt (Co), selenium (Se), and iodine (I) while excess molybdenum (Mo) can also induce copper deficiencies.

Diagnosing Deficiencies :

Unfortunately, the chemical analysis of soils or the plants growing on them (see pages A-41 and A-42), does not provide a reliable guide to the nutrient status of animals for most minerals, with the possible exception of selenium. Tests of animal tissues (e.g. blood) are more reliable, but the response of animals to mineral supplements is the most positive proof of a deficiency. As a result, diagnosing deficiencies becomes a process of accumulating evidence from as many sources as possible and eliminating possible alternatives. This must be done systematically. Data in the following sections covers soil, plant, animal and seasonal factors likely to influence the occurrence of deficiencies and describes both general and specific symptoms.

***Caution* :**

Information in the following sections, especially that on treatments, is meant as a general guide only. Mineral deficiencies are rarely simple and their diagnosis and treatment require the combined efforts of farmers, advisers and veterinarians.

Risk Conditions For Deficiencies:

The most difficult diagnosis to make is when the only symptom is general stock ill thrift, since this can be caused by one of a number of mineral deficiencies as well as factors such as gastro-intestinal parasites and poor management.

Table 1 (page A-33) summarises conditions in which risks of deficiencies of copper, cobalt, selenium and iodine (and excess molybdenum) are greatest. These data can be used to help eliminate possible causes of ill thrift. For example, poor cattle performance on a property where lambs appear healthy eliminates cobalt and iodine deficiency. There are some apparent anomalies in the Table; concentrations of copper and cobalt in herbage are relatively low in both mature material and in very young, rapidly growing plants. The point must be re-emphasised that the factors in Table 1 should only be used as a guide to possible deficiencies and that diagnoses should only be made on the basis of animal tissue tests or production response trials (see "Diagnosing Deficiencies", above).

Table 1: Conditions of Greatest Risk for Trace Element Deficiencies (low Cu, Co, Se and I; high Mo)

	Low Copper	Low Cobalt	Low Selenium	Low Iodine	High Molybdenum
Season -	Spring	Spring/ Summer	Late Spring/ Autumn	Summer	Late Winter/ Spring
Pasture Maturity -	Old see page	Old	-	-	Young
Pasture growth rate -	Rapid A-32	Rapid	Rapid	Rapid	Slow
Pasture species -	Grass dominance, Fescues	Fescue, Cocksfoot, Timothy, Phalaris	White clover, Paspalum, Kikuyu	Goitrogens in the feed (W.Clover, Brassicas, e.g. Kale)	Clover dominance, Yorkshire Fog, Cocksfoot
Soil pH -	High	High	-	High	High
Soil organic matter -	High	High	High	Low	High
Soil water -	Dry	Dry	Wet	-	Wet
Animal species -	Calves	Lambs	Young stock	Newborn lambs	Cattle
Soil contamination -	High	Low	Low	Low	High
Soil types or parent rocks (PR) -	Peats, Sands podzols, shallow rendzinas, upland YB earths	See *Note 1.* below (also see *Figure 2,* page A-40).	Taupo and Kaharoa pumice, peats, N. podzols, gleys, S.I. YG earths, Manawatu sands,coarse acidic P.R. (see map, page A-35)	Sands, inland S.I. areas of sedimentary P.R.	See *Section 2.11.4* on pasture molybdenum
Interactions -	High S, Fe & Mo	Fertiliser N	High S,P	High Ca intake	

*Note 1. **Severe** Cobalt deficiency is found, in the North Island, on Yellow Brown pumice soils formed from the rhyolitic Taupo and Kaharoa ashes, and on strongly leached soils derived from Mairoa ash. In the South Island, on soils derived from granite in Nelson and Westland and the Pakihi soils of the West Coast.*

***Moderate** deficiency (sheep only affected) occurs on leached soils of Northland, and leached/podzolised Yellow Brown earths derived from loess in Southland.*

***Marginal** deficiency probably on the gumland soils of Northland, stony soils in Hawkes Bay, and also coastal sands and soils formed from pumice alluvium. Most areas of Southland can be affected, as can extensive areas of fairly leached stony soils e.g. Lismore stony silt loam and Ruapuna silt loam.*

Selenium Deficiency: ***("White Muscle Disease")***

Occurrence: See Table 1, (page A-33), and Figure 1 (over page).

Signs: See Table 2, (page A-36). Specific diseases include white muscle disease in sheep, cattle and horses, placenta retention in cattle, hepatosis diatetica and mulberry heart disease in pigs and exudative diathesis in poultry. (Although selenium is associated with these diseases, vitamin E may also be involved.)

Diagnosis: Animal tissue analysis; determine glutathione peroxidase in blood, or selenium in blood or liver. Plant analysis gives a reasonable guide. (see Table 3, page A-42).

Treatments:

(a) Oral dosing for sheep:
   - (i) Infertility in ewes and congenital white muscle disease in lambs: 5 mg Se per ewe, 3 to 4 weeks before lambing. (Up to two doses per year).
   - (ii) White muscle disease in lambs: 1 to 2 mg Se per lamb at docking and then 3 to 4 mg Se per lamb at 2 to 3 monthly intervals.

(b) Oral dosing for cattle:
   - (i) Calving problems: mixture of 50 mg Se and 680 IU of vitamin E per cow. Up to six doses of selenium (at least 25 mg per dose) may be given per year.
   - (ii) White muscle disease in calves: 10 mg Se per calf at marking and then 20 to 30 mg Se at 2 to 3 monthly intervals.

(c) Topdress annually with selenium pellets or prills (1% Se)* either alone or mixed with fertiliser at a rate not exceeding 1 kg of pellets per hectare.
** pellets are to contain not more than 10 g of selenium (as sodium selenate) per kg of pellets.*

See over page for map of selenium deficient areas.

Figure 1: *Areas of* *Selenium Deficiency* *Measured by Lamb Growth Trials. (Source: M.A.F.)*

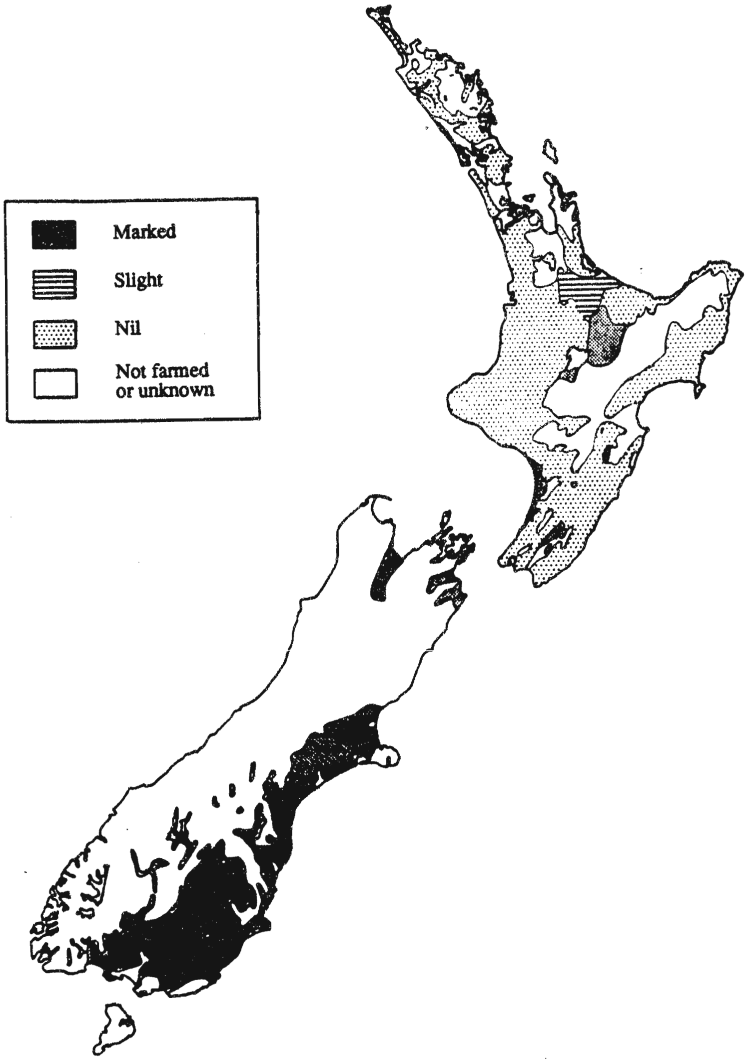


Table 2: Trace Element Deficiency Symptoms of Sheep and Cattle

* = infrequent, ** = more frequent, *** = common.

	Copper (Cu)	Cobalt (Co)	Selenium (Se)	Iodine (I)
Still birth			**	***
Death, sudden	* *(adult cattle)*		** *(young animals)*	
Death, wasting	*	*	*	
Ill-thrift	*** *(calves)*	***	***	
Perinatal weakness (time immediately before and after birth)		*	*	***
Wool/hair defects	***	*	* *(sheep)*	**
Bone fragility	** *(cattle)* *** *(lambs)*			
Lameness	*			
Stiffness			*** *(lambs)* * *(calves)*	
Incoordination	** *(lambs)*			
Infertility	* *(cattle)*	*	*** *(sheep)* * *(cattle)*	*
Gestation prolonged				*
Scouring	*** *(cattle)* *(Mo excess)*	*	*	
Anaemia	*	*		

<u>Order of Severity (1 most severe, 4 least severe)</u>:

	Copper (Cu)	Cobalt (Co)	Selenium (Se)	Iodine (I)
Lambs	2	1	1	1
adult sheep	2	2	2	2
Calves	1	3	2	1
adult cattle	1	4	4	2

Magnesium Deficiency: *("Grass Staggers")*

Occurrence: Occurs on dairy and beef farms, particularly in late winter and spring on lush pastures and when soils and plants are rich in potassium. High plant nitrogen and sodium, and sodium supplementation can also induce Magnesium deficiency.

Signs: Nervousness, staring eyes, stiff movements, staggering, muscle twitching, convulsions, coma, death. In chronic cases there is a gradual loss of condition and a decrease in milk yield.

Diagnosis: Soil and plant analyses are a poor guide to animal Mg status. All tentative diagnoses should be confirmed by determining serum magnesium values (blood tests) from approximately 10 cows.

Treatments:

(a) Drench with 100 g magnesium sulphate or magnesium chloride or with 20g magnesium oxide as fine grade (200 mesh) "Causmag"/calcined magnesite per cow per day during the critical period, three to six weeks before calving, through to at least the end of October. (A mixture of 1 litre pluronic drench, 3 litres water and 2 kg "Causmag" at 45 to 50 ml per cow will supply 100 cows.) Power drenching will keep the "Causmag" in suspension.

(b) Dust dewy pastures with coarse "Causmag"/calcined magnesite (60 mesh) at 0.5 kg per cow per week (at least), more frequently in wet weather. Alternatively apply to hay at 50g per cow per day (see (d) below).

(c) Add magnesium chloride to drinking water at 3 g per litre. May take 2 to 3 weeks for full acceptance by stock.

(d) Treat hay fed at the rate of 10 to 15 cows/bale with calcined magnesite in a watery molasses solution to provide 50 g/cow/day. Apply to cut edge of bale.

(e) Magnesium fertilisers may increase concentrations of magnesium in herbage if the magnesium soil test is less than 8, but this will not guarantee either the prevention or cure of hypomagnesaemia.

Calcium Deficiency: *("Milk Fever" or "Lambing Sickness")*

Occurrence: Simple calcium deficiency is rare in New Zealand but young animals grazing pastures containing less than 0.25% Ca could be marginally deficient. Milk fever is a metabolic disease which can occur when dietary calcium is apparently adequate.

Signs: Milk fever or parturient paresis. Restlessness, inappetance, general inertia, muscle tremors, staggering and collapse.

Diagnosis: Low plasma calcium and the above signs.

Treatments: Animals with milk fever should be propped up, kept warm and treated with calcium borogluconate (administered subcutaneously or intravenously).

Copper Deficiency:

Occurrence: See Table 1, (page A-33).

Signs: See Table 2, (page A-36). Steely wool on sheep is characteristic and while changes may occur in cattle hair colour, they are not solely characteristic of copper deficiency. Enzootic ataxia ("sway back") and bone fragility in sheep. Cattle are more sensitive to copper deficiency than sheep. Signs are poor growth, reproductive problems and diarrhoea. Post parturient haemoglobinurea occurs in dairy cattle.

Diagnosis: Animal tissue analysis: for cattle determine serum copper or ferroxidase activity or liver copper concentration (on live stock, or culls after slaughter); for sheep determine liver copper concentration. Plant analysis is unreliable for diagnosis, but knowledge of the concentrations of copper, molybdenum, sulphur and iron may help to determine the cause of a deficiency. Although critical values are not known with any precision, concentrations of molybdenum, sulphur and iron greatly in excess of normal values can induce copper deficiency even at copper concentrations normally considered adequate (5 to 10 ppm for sheep, 10 ppm for dairy cattle). Large intakes of zinc can also impair copper absorption. The equation incorporating the influence of herbage molybdenum and sulphur on copper availability to stock (known as suttle's formula) does not appear to be accurate for grazing animals in N.Z. conditions.

Treatments:

(a) Fertilisers*: on peat - apply 10 kg copper sulphate per hectare initially, then 5 kg/ha every 3 years. Other soils - apply 5 kg/ha every 5 years *(Source: M. O'Connor, in "N.Z. Farmer", Aug. 1987).* Use only when copper deficiency is confirmed and when copper concentrations in herbage are less than 5 ppm. If copper deficiency is due to excess molybdenum, etc, copper fertiliser will have little value.

* *Note: Fertilisers containing copper sulphate can be toxic to stock, and advice should be sought before topdressing.*

(b) Injection:

	Dose (mg)	Frequency Doses/year
Sheep - up to 1 year	2 - 6 mg	1 - 2
- adult	6 - 12	1 (pre-lamb)
Cattle - up to 1 year	50 - 120	1 - 3
- 1 to 2 years	50 - 250	1 - 3
- adult	50 - 250	1 - 3

(Source: M. O'Connor, in "N.Z. Farmer", Aug. 1987).

(c) Use salt blocks containing 5 to 10 kg copper sulphate per tonne.

Cobalt Deficiency:

Occurrence: See Table 1, (page A-33) and Figure 2 (over page). Can occur in marginally deficient areas when lax summer and autumn grazing of fattening lambs and hoggets minimises soil ingestion.

Signs: See Table 2, (page A-36), there are no specific symptoms.

Diagnosis: Animal tissue analysis; determine vitamin B12 concentration in sheep serum or in liver for both cattle and sheep. Liver storage of B12 reserves make plant cobalt analysis unreliable for diagnosing deficiencies in animals.

Treatment: Cobaltised fertiliser is the recommended preventative measure.
New pasture on severely deficient soils:

- 350 g/ha of Cobalt Sulphate annually for 8 to 10 years then reduce to 175 g/ha every three years.

Moderately or marginally deficient soils:

- 175 g/ha Cobalt Sulphate on approximately one third of the farm in spring. Rotate lambs through the treated area after weaning.

- Other forms of treatment include pasture spraying, injections, treated drinking water, drenching, licks or cobalt "bullets". *Source: M. O'Connor, in "N.Z. Farmer", Aug. 1987.*

Sodium Deficiency:

Occurrence: Occurs in sheep and cattle during lactation and on low sodium diets, and also on light soils receiving excessive amounts of potassium fertilisers.

Signs: Craving for salt indicated by licking wood, the sweat of other animals and occasionally soil; poor appetite, ill thrift, rough coat, lustreless eyes, loss of weight and decline of milk yields.

Iodine Deficiency:

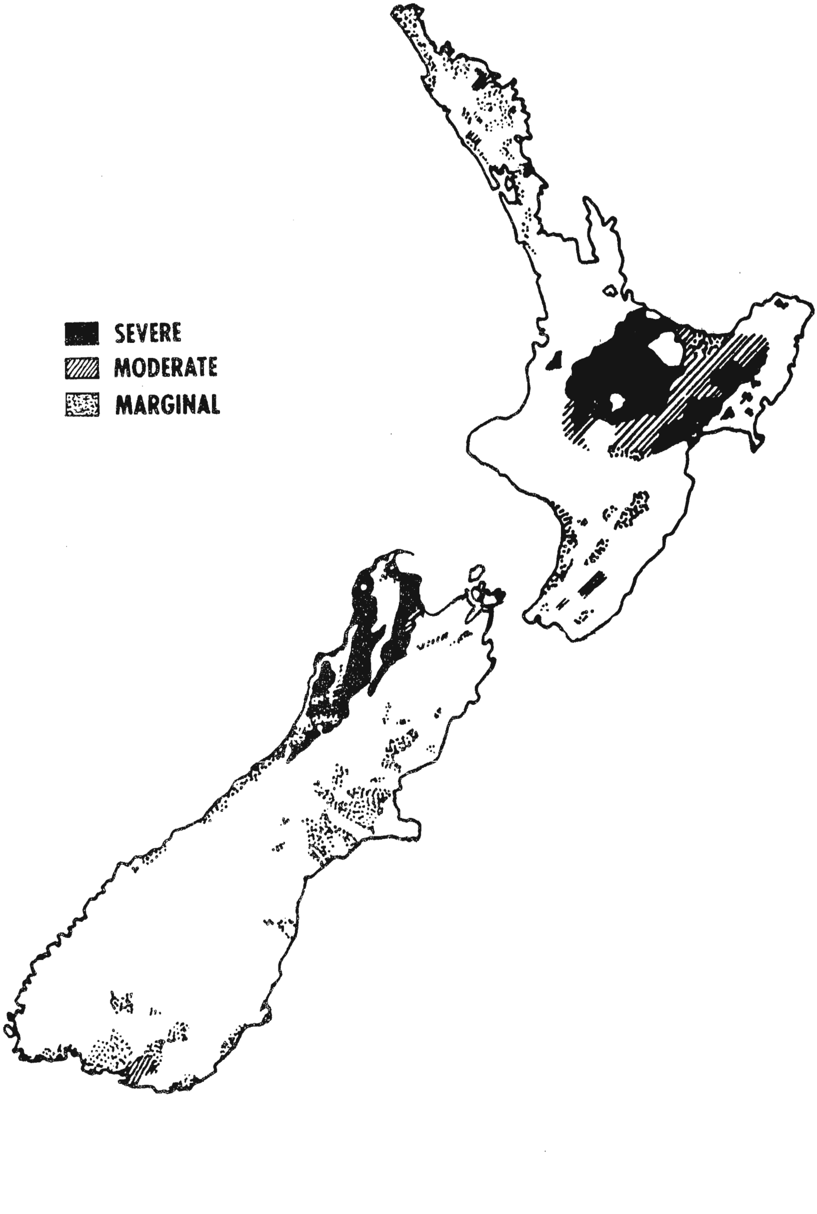
Occurrence: See Table 1 (page A-33).

Signs: See Table 2 (page A-36). Specific signs are woolless patches and oedema (accumulation of fluid in tissue) in newborn lambs. While goitre (enlarged thyroid gland) may be caused by iodine deficiency, it can also be caused by goitrogens (in feed, e.g. Kale) or inherited.

Treatment:

(a) Salt blocks containing 200 g potassium iodate per tonne.
(b) Two oral doses containing 240 mg potassium iodide, at the beginning of both the fourth and fifth month of pregnancy.
(c) Inject with 1 ml iodated poppy-seed oil containing 40% iodine, 7 to 9 weeks before lambing.

Figure 2: *Distribution of Cobalt Deficient Soils (Source: M.A.F.)*



Mineral Content in Feed: *(see Note 1. below for sampling procedure)*

The survival and productivity of farm animals depends on adequate supplies of a number of mineral elements. *Table 3* (over page) lists estimated concentrations in feed which, if feed intake and nutrient availability in the feed were normal and adequate, would ensure adequate daily supplies. These are only approximations; animals may obtain nutrients from sources other than the feed sample analysed while factors such as soil contamination and other plant constituents may influence the availability of feed nutrients to stock. *The amount of feed, and hence minerals, consumed is far more important than the concentration of minerals in the feed.* Animal mineral requirements also depend on rates of growth or production.
As a result, feed analysis and the values in Table 3 should not be used exclusively to make a positive diagnosis of deficiency. Concentrations well in excess of values in Table 3 probably indicate adequate supplies, but if values are less than those shown, animal tissue analyses should be taken to confirm diagnosis.

Note 1: The procedure for taking pasture samples for laboratory analysis is similar to that described on page B-48. Clippers should be used, especially in wet conditions, to avoid soil contamination. The pasture should be clipped down to grazing height, and the herbage should be loosely packed into paper bags and dispatched to an analytical laboratory with the minimum delay. Farm consultants or veterinarians can assist with this operation, and also with the interpretation of the results.

See over page for Table 3.

Table 3: ***Mineral Content Required in Feed for Sheep and Cows***
These estimates must be used with care; please read cautionary notes on pages A-32, A-41, and see *Note* 2, below.

		Concentration in *Feed Dry Matter* for:	
		Fattening Sheep	Milking Cow
Major Minerals/Elements:			
Calcium	Ca	0.29%	0.44%
Phosphorus	P	0.20%	0.32%
Sodium	Na	0.09%	0.12%
Chlorine	Cl	0.10%	0.24%
Magnesium	Mg	0.12%	0.19%
Potassium	K	0.36%	0.58%
Sulphur	S	0.14%	0.18%
Minor Minerals/Elements:			
Iron	Fe	30 ppm	40 ppm
Manganese	Mn	25 ppm	25 ppm
Copper	Cu	5-10 *(see Note 3)*	7-10 *(see Note 3)*
Zinc	Zn	25 ppm	25 ppm
Cobalt	Co	0.11 ppm	0.04 ppm
Selenium	Se	0.03 ppm	0.03 ppm
Iodine	I	0.20-2.0 *(see Note 4)*	0.50-2.0 *(see Note 4)*

Note 2. These values should give adequate mineral intakes assuming normal mineral availability and adequate feed intake. With the exception of selenium, the values were obtained from feeding trials done overseas. While published estimates vary considerably, the values represent the most recent North American and British Standards.

Note 3. Depends on concentrations of Mo, S, Fe, etc.

Note 4. 2 ppm Iodine recommended when feed includes goitrogens (e.g. Kale).

1.3.3 Some Common Diseases of Livestock

Note: See Section 3.1.3 for stock health problems on forages.
See Section 1.3.2 for common mineral deficiencies of livestock.
See Section 1.2 for temperature, pulse and respiration norms for livestock.

Brucellosis of Cattle

(Source: M.A.F.)

Brucellosis of cattle is a highly infectious disease caused by the bacterium *Brucellosis abortus.*

The principal symptoms of brucellosis in cattle are abortion and the premature birth of dead or weak calves; hence the older name "contagious abortion".

Brucellosis is usually transmitted from one cow to another by ingestion of infective material, such as discharges and membranes passed during an abortion. The greatest danger period is the first 12 hours after abortion or calving. Fortunately brucellae seldom survive more than 30 days on pasture. However they may survive in effluent for up to 6 months.

Leptospirosis

(Source: M.A.F.)

Leptospirosis is the most common serious zoonotic infection present in New Zealand. It is essentially a disease of people who milk cows, with about 90% of notified cases occurring in dairy farmers.

Leptospirosis is the infection caused by the bacterium *Leptospira interrogans*, an obligate parasite of mammals.

In New Zealand, approximately two-thirds of human cases of leptospirosis are due to serovar *hardjo*, one-third to *pomona* and only a few cases to other serovars.

* *Hardjo* infection is endemic throughout the country and virtually all unvaccinated dairy herds are infected.
* In New Zealand, whenever outbreaks of *pomona* infection in cattle have been thoroughly investigated, infection has been traced directly or indirectly to pigs.
* Cattle vaccines against *L. hardjo* as well as *L. pomona* are highly effective when used correctly. However, once the vaccine has been used on the herd, it must be boosted each year.

"Ryegrass Staggers"

Ryegrass staggers is caused by a mycotoxin produced in ryegrass plants by an *endophytic* fungus. See pages B-4 and B-5 for endophyte incidence in cultivars of ryegrass.

"Grass Staggers"

See Magnesium Deficiency, page A-37.

Facial Eczema
Facial eczema causes extensive losses in livestock through lowered production and death arising from liver damage. The disease occurs mainly in the North Island during or after periods of warm humid weather between January and April. Harm to stock is caused by ingestion of the toxin sporidesmin, produced by the spores of the fungus *Pithomyces chartarum.*

There are several methods of control:

(1) Zinc sulphate supplied daily through the water supply (not suitable for sheep or deer), or zinc oxide by drenching or pasture spraying/dusting (for recommended rates contact local veterinarian or consultant).

(2) Selection of 'safe' pastures through the use of microscope (spore counting).

(3) Stock management so that animals are prevented from eating dangerous levels of spores, e.g. graze on "safe" crops - maize, lucerne, kale, rape, or hay and silage.

(4) Pasture Sprays:
In areas of high incidence and during danger periods (see above), spraying with fungicides (see below) is recommended. Either spray all paddocks, or only those to be grazed when there are high levels of spores present, (use spore counting to determine danger periods).

Several fungicides can be used and as a general rule, paddocks should be sprayed well ahead of grazing.

* Benomyl (Benlate) 300 grams in 100 to 450 litres of water per hectare, at least 24 hours (preferably 10 days) prior to grazing.

* Thiophanate - methyl (Topsin M-4A) 350 to 700 ml in 100 to 200 litres water per hectare, depending on severity of infestation likely (from historical information). Effective for six weeks, unless heavy rain falls. Complete re-treatment is necessary in this case.

* Carbendazin (Delsene 50DF or Bavistin FL)
Delsene: 200 grams in 100 to 450 litres water per hectare
Bavistin: 300 ml in 100 to 200 litres water per hectare, at least 24 hours and preferably several days, prior to grazing. As above, protection lasts for about six weeks unless it rains heavily.

"Milk Fever"
See Calcium Deficiency, page A-37.

Johne's Disease - Sheep, Cattle, Goats, Deer.
(Source: M.A.F.)
Johne's disease, or paratuberculosis, is a chronic intestinal disease of ruminants caused by *Mycobacterium paratuberculosis.* Infection with this bacterium produces a thickening of the intestinal wall which interferes greatly with absorption of nutrients and water.
Johne's disease causes serious economic losses resulting from shortened life expectancy and reduced productive capacity during the long preclinical stage of the disease.
Because of the slow course of disease, outbreaks do not occur. Rather, in an infected herd or flock clinical cases occur sporadically.

Signs of the disease:
Most clinical cases occur between 2 and 6 years of age in cattle and between 2 and 4 years of age in sheep and goats. In cattle the main feature of the disease is diarrhoea. The main clinical sign of the disease in sheep is a loss of body condition due to resorption of body fat and wasting of muscles.

Because Johne's disease spreads slowly it may be years before a herd or flock is recognised as being infected.

Hydatids (Control)
Requirements for control are:
(1) The regular dosing of all dogs from the age of 3 months.
(2) All sheep and goat meat fed to dogs must be cooked thoroughly or frozen to minus $10^{\circ}C$ for at least 7 days. Offal must be burnt or deeply buried, or disposed of in approved-design offal pits.

Footrot of Sheep *(Use of Zinc Sulphate for Footbathing)*
(Source: M.A.F.)

The recommended concentration of zinc sulphate is 10% in water, that is 1 kg per 10 litres of water (mixed thoroughly). The footbath should be filled to a depth of 8 cm so that sheep will stand with their hooves completely immersed. Keep sheep standing in the footbath for at least two minutes. The sheep should then be held in the yards on dry ground or on a slatted woolshed floor for at least 15 minutes to allow the action of the chemical in the feet to continue. Repeat footbathings at weekly intervals when treating flocks for footrot.

Diseases of Deer *(Note: See also pages A-43 to A-45)*

Disease	*Symptoms*	*Control/Treatment*	*Remarks*
Malignant Catarrhal Fever (M.C.F.)	Become depressed. May lag to rear of herd, scour and refuse to eat. Death usually occurs within 24 hours of development of recognisable signs, and may happen without any clinical signs. Two forms: intestinal; head and eye.	Control: Antibiotics are ineffective against viruses, death is almost inevitable, therefore animals suspected of having the condition should be separated immediately. Reduce contact.	Probably the most serious disease affecting farmed red deer. Occurs throughout the year, but most deaths occur in the winter. Thought to be caused by bovine malignant catarrh (BMC) virus, which may be carried by sheep.
Yersiniosis	Affected animals are depressed and lag behind. Scouring occurs. Often the condition is acute and deer are found dead.	Treatment: Any associated stress should be identified and corrected. Antibiotics are by injection or orally in feed or drinking water. An affected herd should be spread out.	Has become a major disease in recent years. In some species causes abscesses which resemble tuberculosis. It can be isolated from faeces of clinically normal deer.
Tuberculosis	Generally chronic (long-lasting)wasting condition. No specific clinical signs are seen. In a few cases abscesses have appeared over rib cage.	Control: Use of the tuberculin test; deer coming onto a property should be tested. Animals found with the disease should be destroyed, not treated.	The bacteria can be inhaled or ingested with grass or water, or when one animal licks the coat of another. Testing for Tuberculosis is compulsory.

Diseases of Deer (Continued)	*Symptoms*	*Control/Treatment*	*Remarks*
Clostridial Infections	Generally young animals are infected. They become depressed, may stagger and may have severe, often bloody, diarrhoea. Death follows rapidly. Animals generally found dead.	Prevention: Vaccination is the best method. Sheep vaccines are not yet registered for deer. Seek veterinary advice before vaccinating. The following times are a general guide: Calves - weaning; Hinds - 6 weeks before calving (stimulates colostral immunity).	Clostridial bacteria cause the familiar conditions of pulpy kidney, blood poisoning and tetanus in farmed animals.
Enzootic Ataxia *(See also page A-38, Copper Deficiency).*	Affected animals appear bright but when made to run, sway in hind quarters and appear weak in hind legs. If disease progresses, fore legs also weaken, and the animal lies down.	Treatment: Ineffective once symptoms have appeared. Prevention: Seek veterinary advice before using copper injections, capsules of copper oxide, or copper topdressing.	Appears to be caused by copper deficiency. Largely confined to adults. Should always be confirmed before prevention programmes are initiated. (Ryegrass Staggers can cause similar symptoms. Other symptoms of copper deficiency can be observed in young animals).
Lungworm	Coughing, ill-thrift, parasitic pneumonia, and in severe cases death. These symptoms are not exclusive to lungworm infestation. First stage lungworm larvae may be found in faeces.	Control is based on the worms' life cycle. Recommendations: 1. Assume that a lungworm problem will recur unless appropriate control measures are taken.	It is not known if deer develop immunity as cattle do. The presence of lungworm in lungs (found in post mortem) or in faeces does not necessarily indicate a pathogenic burden of lungworm. Although deer may

Continued Over Page

	Control/Treatment	***Remarks***
Lungworm (Continued)	2. Lowering the stocking rate can decrease the larvae density on pasture. 3. Drench calves in early March or at weaning and put on to clean pasture. The most heavily contaminated pasture is where hinds have calved and calves raised. 4. If clean pasture is not available calves should be treated with an effective anthelmentic every 21 days from early March until winter. Use broad-spectrum drenches. 5. If deer are set-stocked, susceptible animals should be treated every 21 days during their first season to kill the acquired lungworm before they commence laying eggs. The low effectiveness of drenches against severe lungworm infestations emphasises the importance of control measures to prevent the development of a severe out-break. All stock should be protected. Very little information on lungworm is available. Vaccination of deer calves for control can not be recommended.	carry an infestation at any time during the year, lungworm appears to be most important during autumn and early winter. Veterinary advice in the development of effective control programmes is essential.

	Symptoms	***Control/Treatment***	***Remarks***
Tissue Worm	Of minor importance except in export animals. However three types of reaction to infest-ation can occur: 1. Acute - characterised most commonly by paralysis of the hind limbs. 2. Chronic - ill thrift. 3. Type of pneumonia induced by migration of larvae through lungs. An infestation is diagnosed by finding of characteristic Elaphostrongylus larvae in the faeces or washings from the lungs.	At present there is no first hand experience on effective anthelmintic treatment available in New Zealand.	Problems of identification. Control of intermediate hosts and anthelmintic control are being investigated.

***(Source: M.A.F.** Updated in 1990 by A.S.Familton, Animal and Veterinary Sciences Department.)*

1.4 SHEEP

1.4.1 Feed Requirements and Liveweight Charts of Sheep

See pages A-5 to A-10 inclusive.

1.4.2 Breeding, Age and Physiological Information of Sheep

See pages A-26 to A-29 inclusive.

1.4.3 Sheep Health and Diseases

See pages A-30 to A-45 inclusive.

1.4.4 Wool

See pages A-53 to A-69 inclusive.

1.4.5 Sheep 'Stock Unit' Measures

See pages A-100, A-101.

1.4.6 Sheep Performance on New Zealand Farms

See pages G-6, G-7.

1.4.7 Lambing Percentage Calculations

There are several common methods of calculating the lambing percentage figure:

1. $\frac{\text{Number of lambs docked}}{\text{Number of ewes to ram}} \times \frac{100}{1}$

2. $\frac{\text{Number of lambs docked}}{\text{Number of ewes alive at docking}} \times \frac{100}{1}$

3. $\frac{\text{Number of lambs surviving to sale}}{\text{Number of ewes put to the ram}} \times \frac{100}{1}$

4. $\frac{\text{Lambs born}}{\text{Ewes lambing}} \times \frac{100}{1}$

5. $\frac{\text{Lambs born}}{\text{Ewes to ram}} \times \frac{100}{1}$

Normally the difference between the 2nd and 3rd calculation is only in the order of 2 to 4%. The docking % is the one most commonly used.

The 3rd calculation is the only correct one for budgeting and should be used in preference to 1 and 2.

Calculation 4 over estimates the true lambing % as it takes no account of dry ewes or ewe deaths since mating.

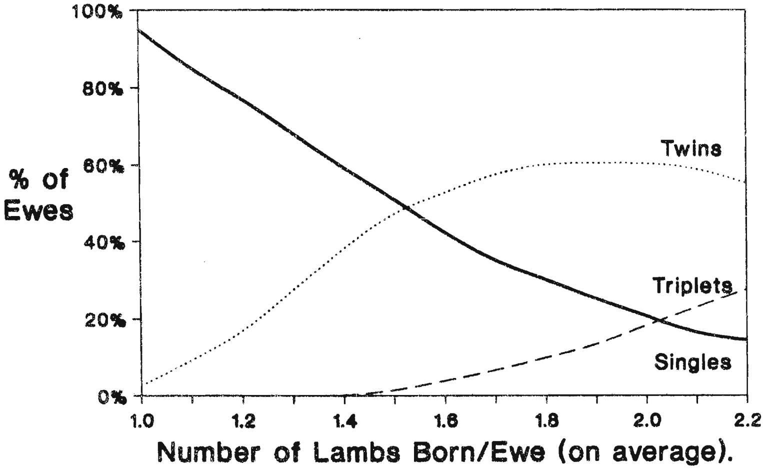
Calculation 5 is a reflection of the reproductive potential of the flock. If there is a larger discrepancy (i.e. > 15%) between this estimate and calculation 2 it indicates some management changes may be required.

1.4.8 Lambs Born: Proportions of Singles, Twins and Triplets

(Source: M.A.F.)

Figure 1 (below) shows the influence of lambing percentage on the numbers of singles, twins and triplets born.

Figure 1: Proportion (%) of ewes producing singles, twins and triplets.



1.4.9 Death Rate or Mortality

The average mortality for a ewe flock on low country is 4% to 5%. On harder country, this figure is higher. On South Island high country runs, 6 to 10% overall is common with occasional losses of greater than 15%.

Average death allowances are 2 to 3% for hoggets and 3 to 4% for export lambs.

1.4.10 Rams

It is usual to buy rams as 'one-shear' or 18 month of age by private treaty. A small number are purchased at local ram fairs. The average farmer buys flock rams. Rams last 'on average' four breeding seasons and are usually disposed of by killing for farm dogs. On New Zealand hill country one ram per 100 ewes is a common ratio but, this depends on the breed and the type of country. In general the harder the country the lower the Ram:Ewe ratio.

1.4.11 Rotational Grazing/Mob Stocking - Some Cautionary Notes

(Source: M.A.F.)

Some problems can occur when farmers have to handle large mobs (2000 to 3000 ewes or more). These can be due to:

* The pressure stock exert on each other and on structures such as fences, gateways, culverts, during movement of mobs.
* High density of grazing, causing an urge to break out through fences.

New structures:
When further sub-division is required, fences and gateways should be built to assist stock movement. Gateways should be 4 metres wide and away from awkward corners. Electric fences can have the advantage of "giving-way" under severe pressure of large numbers of stock rather than causing a fatal pile-up.

Existing conventional fences:
Should be in good condition and stock proof. If there is a weak point through which one or two sheep can escape this may lead to a massive movement of stock to that point.

Existing Gateways:
Should be improved or maintained so that there are no muddy holes to impede the flow of stock. Exits from gateways are important. To enable stock to move away readily from the gate area, repair or upgrade areas such as culverts and narrow tracks.

Planning stock movements:
Stock movements should be planned in advance. If possible use the more difficult gullies and sidings, and the worst gateways and crossings, early in the winter before the sheep are heavily in lamb.

Aim to shift stock at regular intervals, for example: each 24 hours or each 48 hours. They will then come to expect the shift to new pasture and will be less likely to force through fences.

Other management suggestions:
"Rogue" stock may continually jump or push through fences. If this activity cannot be stopped within a short time, it may be wise to remove these sheep.

Wherever possible avoid disturbances of stock at other than planned moving times.

1.5 WOOL

1.5.1 Wool Production/Sheep Performance on New Zealand Farms

See pages G-6, G-7.

1.5.2 Shearing Times and Intervals

(Source: New Zealand Wool Board, 1990).

Adult sheep are usually shorn once per year; dry sheep in September - October, and breeding ewes after the dry shearing. Alternatively, ewes may be shorn pre-lambing (usually August). The practice of shearing three times every 2 years (pre-lambing every second year) is also used by some farmers. Shearing twice a year is common in high wool producing flocks in the North Island.

Multiple Shearing:

The first general rule is that the wool should not be too short ; that is not less than 75 mm (3 inches). The optimum and preferred length is 75 to 125 mm.

Shearing has to fit around the fixtures in the calendar: lambing, weaning and tupping (it is important not to shear too close to tupping). This gives three main choices:

- Pre-lamb and pre-tup. The first shearing has the same cautions as main shearing at that time. The second runs into the risk of a dry summer (lack of feed) with the sheep losing condition (see page A-7).
- Pre-wean and pre-tup. The first shearing has the problem of lambs at foot, and with the second, you should be sure of adequate length.
- Post-wean and post-tup. This puts the break into mid-staple for the first shearing but gives the flock better feed after the second. Summer discolouration is less of a concern with the shorter wools. Wool weights should be better with this regime but pregnant ewes need careful handling.

Finally, shearing can take place every eight months. This avoids the likelihood of producing unduly short wools and has other management advantages. Times are about mid-January, then spring, and complete the cycle in May. In the South, the times could be immediately after weaning in December, pre-lambing in August and pre-tup in March.

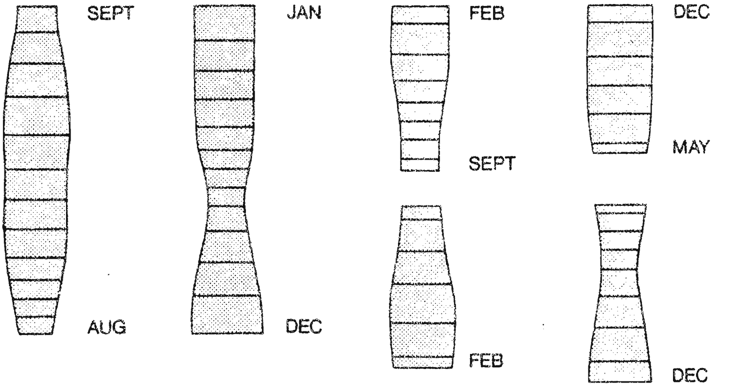
It works even better if the flock is split into two as shown in *Table 1* (below). The groups would be run together and drafted before shearing.

Table 1: *The shearing pattern for split flock multiple shearing over two years. There is a shearing every four months:*

	J	F	M	A	M	J	J	A	S	O	N	D
Year One				A				B				A
Year Two				B				A				B

(Source M.A.F.)

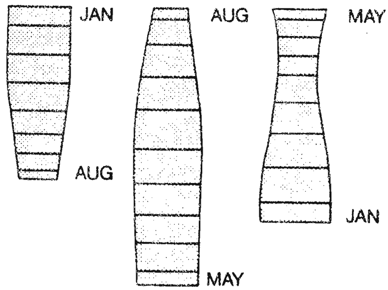
The relative growth and fibre diameter of the wool month by month under a multiple shearing regime, is shown diagrammatically in *Figure 1:*



Above: Single shearing in early spring and around Christmas.

Above right: 2 regimes of second shearing.

Right: Wool shorn three times in two years.



Crutching:

Lambs which are not shorn are crutched in January-February. Ewes are crutched in June-July and may also be lightly crutched or "ring-crutched" before rams go out.

1.5.3 Wool Grading

(Source: New Zealand Wool Board, 1990)

Grading Crossbred Wools:
It is generally not necessary to class into more than one line unless there is an obvious difference in micron (see *Section 1.5.4*) or the clip is a large one. The aim should be to create one main line removing only the fleeces that do not match the bulk. More care should be taken with hogget wools, which fall into the fine end of the crossbreds.

There are price differences for colour (see *Section 1.5.5*) and length (see *Section 1.5.6*). If mobs are bought in, shorn at different times or grazed under different conditions and have clear distinctions, the wool should be put into mob lots.

With clips of even colour, the following wools should be kept separate from the main lines:
* All cotts.
* Discoloured fleeces.
* Very short or very tender wools in an otherwise sound clip.
* Very high vegetable matter.

In other words, separate those that do not match the main line.

When the clip is of poorer colour, remove:
* All cotts.
* Fleeces that do not match for colour, length, VM etc.

Grading Finer Wools:
Wools finer than 33 microns (Corriedale, Halfbred and Merino) should be handled by a registered classer. They will be classed for fineness - usually fine, medium and strong. Secondary lines of off-type fleeces will cater for those of very different length (see *Section 1.5.6*), colour (*Section 1.5.5*) or with significant faults.

The following descriptions should be used as applicable but in most clips only two or three main lines will be required for fineness (see also *Section 1.5.4*).

Merino:

Extra fine	18 microns and finer
Fine	19-20 microns
Medium	21-22 microns
Strong	23-24 microns

Halfbred and Corriedale:

Extra fine	25 microns and finer
Fine	26-27 microns
Medium	28-29 microns
Strong	30-31 microns
Extra Strong	32 microns and coarser

With clips of average colour and better, the following fleeces should be kept separate:
* All cotts.
* Discoloured fleeces.

* Fleeces with heavy vegetable matter.
* Very short or tender fleeces in an otherwise sound clip.

The important thing is to avoid over-classing. It is a common mistake to make lines with only slight differences. The classer should make the fewest lines possible, with very clear distinctions for average fibre diameter of at least 1 micron in Merino and Halfbred clips and 1 to 2 microns in Corriedales.

The classing should be structured to avoid small lines as they will usually be combined with other clips prior to sale. Similarly, the number of reclass fleeces to be binned should be kept to a minimum.

Small lines are justified for wools 19 microns or finer, which can bring substantial price premiums.

Grading second shear:
The sheep should be drafted if they have been bought in or shorn at different times and the difference in fleece length exceeds 50mm (2 inches). Second shear wools are generally uniform in colour. Make one line, removing fleeces that are very poor colour or much shorter than the majority (see also *Section 1.5.6*).

Grading Lambs Wool:
Lambs' bodywool will go into one line except very short wools, milk lambs, or very coarse or lustrous wools that do not match the bulk. Do not put short lambs wool into bellies and pieces, even very short ones. They are worth more and should be kept separate for binning.

1.5.4 Fineness (Micron) of Fleece

(See also page A-55)

Fineness is an important price determinant. Premiums for fineness reflect the value of softness and lightness of apparel; the flexibility of each fibre improves rapidly as the diameter decreases. Even so, the classer of a fine wool clip should not make too many lines for fineness and there should be a distinct difference of at least 1 micron between them (see page A-55, and above).

Fibre fineness is measured in micrometres (microns), the normal range being between 19 (fine) to 40 (coarse). The micron ranges for different sheep breeds are given on page A-63.

The relationship between quality number and micron is given in *Table 2*, over page. As fibre diameter or micron measurement of the wool increases, the quality number decreases, indicating that coarser wools can not be spun to such fine counts. Also given in the table, is the linear density or tex value of the fibres, in grams per 1000 metres. This is a valuable guide to the processing properties of the fibre, as the cross-sectional area of the fibre is more important than its diameter. It is the cross-sectional area which determines linear density and yarn count.

Table 2: Micron/Quality Number Relationships
Source: Lincoln University Wool Manual 1990 (Wool Science Department).

Mean Fibre Diameter (microns)	Quality Number	Linear Density or Tex (g/1000m)*	Mean Fibre Cross-sectional Area (μm^2)
15	100s	0.23	177
16	90s	0.26	201
17	80s	0.30	227
18	70/80s	0.33	254
19	70s	0.37	283
20	64/70s	0.41	314
21	64s	0.45	346
22	60/64s	0.50	380
23	60s (Merino)	0.54	415
24	60s (Quarterbred)	0.59	452
25	58/60s	0.64	491
26	58s	0.69	531
27	56/58s	0.74	572
28	56s (52/56s lambs)	0.80	615
29	54/56s (50/52s lambs)	0.86	660
30	52/54s (50/48s lambs)	0.92	707
31	52s (46/50s lambs)	0.99	754
32	50/52s	1.05	804
33	50s (44/48s lambs)	1.12	855
34	48/50s	1.18	907
35	46/50s or 48s	1.26	962
36	46/48s	1.33	1017
37	44/48s or 46s	1.40	1075
38	46/40s	1.48	1134
39	40/46s	1.56	1194
40	36/44s or 40s	1.64	1256
41	-	1.72	1320
42	-	1.81	1385
43	-	1.90	1451
44	-	1.98	1520
45	-	2.08	1590

* *The tex value of a single wool fibre = radius^2 x 0.0041*

1.5.5 Wool Colour (See also page A-55, 56)

Sources: N.Z. Wool Board publications, and Lincoln University Wool Manual 1990 (Wool Science Department).

The colour of wool, after scouring, is very important from a commercial point of view. Many yellow discolorations and stains are scourable but there are several that are not (washing a few samples under the tap can give a rough guide as to whether the discoloration is permanent or scourable).

New Zealand wools are noted for their good colour, particularly valued when pastels are popular. Colour is an important factor in fixing price, particularly for crossbred wools.

Most farm lots are colour tested for the information of buyers and processors. It is not possible to use only one figure to describe wool colour and the two used are: Y = brightness or lightness, and Y-Z = whiteness or yellowness. (Y is a measure of the green in the colour, Z the blue and X the red). The lower the Y-Z value the whiter the wool, the higher the Y-Z value the yellower the wool. Very white wools have Y-Z values that can be 1 to negative numbers. Very yellow wools have a value of over 10.

Typical colour readings for New Zealand wools are:

Fleece Colour

	X	*Y*	*Z*	*Y-Z*
White	64.5	66.0	65.0	1.0
Off White	56.5	60.0	56.0	4.0
Creamy	52.0	55.0	47.5	7.5

Further information on colour grades and colour values is presented in *Table 3 (below) and Table 4 (over page).*

Table 3: Colour Grades

Brightness (lightness)	*Y*	*Whiteness (or Yellowness)*	*Y-Z*
very bright	>68.0	very white	<1.0
bright	65.0-68.0	white	1.0-2.9
average brightness	62.0-64.5	creamy/pale yellow	3.0-4.9
dull	58.0-61.5	yellow	5.0-7.9
very dull	<58.0	very yellow	>8.0

See over page for Colour Values

Table 4: Colour Values

Breed	***Y values:***			***Y-Z values:***		
	Good	Average*	Poor	*Good*	*Average**	*Poor*
Merino	>67.5	67.5-65.0	<65.0	<1.5	1.5-2.0	>2.0
Halfbred & Corriedale	>65.0	65.0-62.0	<62.0	<2.5	2.5-3.0	>3.0
Romcross	>62.0	62.0-58.5	<58.5	<4.5	4.5-5.5	>5.5

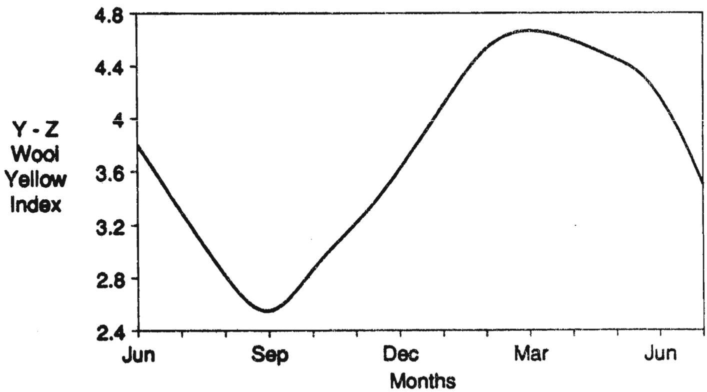
**Average Style - Merino B, HB/COR B, Romcross B/C*

Experience with colour measurement can help growers choose the optimum time to harvest their wool and to determine the shearing intervals that suit their environment.

Spring/early summer shorn wool often has much better colour than autumn/winter shorn wool.

Figure 2 shows the changes in colour of wool throughout the year (yellowness increases rapidly with the onset of summer).

Figure 2: Colour of Wool Throughout the Year



1.5.6 Wool Length (See also *Section 1.5.3*, page A-55).
Source: N.Z. Wool Board.

Staple length is important in price setting. With crossbred wools, the optimum length is 100 to 125 mm. Wools shorter than 75 mm are usually discounted and there is no premium over 150 mm. With lambs, the shorter wools are finer and earn a premium on that account. Fine wools are shorn annually and length is determined by feed and climate, but a minimum of 75 mm should be sought with Merinos.

1.5.7 Clean Wool Yield
Source: Lincoln University Wool Manual 1990 (Wool Science Department)

This is the percentage of clean wool in the 'greasy weight' after grease, dust etc. has been removed.

Table 5: Clean wool yields of full fleece* wool (average %).
Category F2 (fleece wool B grade)

Breed	*Micron*	*Average Yield %*
Merino	19	69
	21	70
	23	71
Quarterbred/Halfbred	24	70
Corriedale	26	71
	28	72
	30	73
	31	74
	33	74
Crossbred	30	75
	31	76
	33	77
	35	78
	37	78
	38	78
Lustre (Leicester)	40	78
Speciality Carpet (Drysdale)	41	79

* **Note:** ***Second shear*** *body wools of good average length yield similarly to full fleece wools but short, second shear cross-bred wool may yield 2 to 3% higher.*

Table 6: Average percentage clean wool yield of <u>oddments</u> of good/average grade

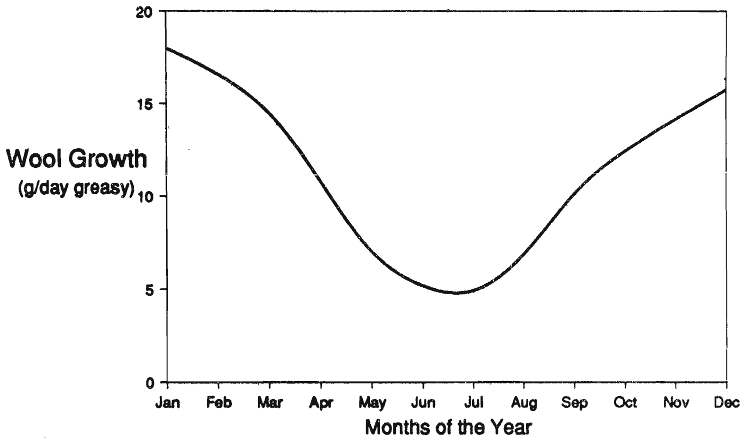
Breed Group	*Micron*	*Necks %*	*First Pieces & Crutchings*	*Bellies %*	*Second Pieces & Locks %*	*First Crutchings %*	*First Lambs %*
Merino	21	66	62	60	51	60	66
Quarterbred/ Halfbred	28	70	62	59	52	62	70
Crossbred	35	77	68	65	58	70	80
Lustre	40	68	-	62	-	75	80
Speciality Carpet	41	-	-	-	-	68	79

1.5.8 Wool Growth

(Source: New Zealand Wool Board, 1990)

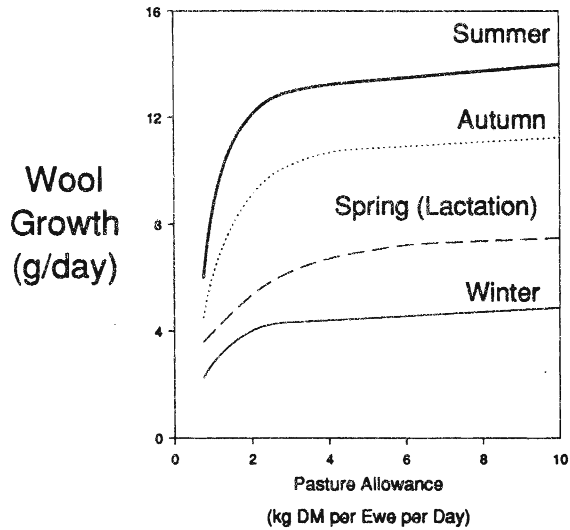
With Romney-type sheep, wool growth is controlled by the daylight hours (see *Figure 3*). With Merinos, it is mainly a matter of feeding, and with Corriedales and Halfbreds, it is a little of each.

Figure 3: The Cycle of Wool Growth, governed for Romney-type sheep by daylight hours.



In winter, wool growth in Romney-type sheep drops to about a third of summer growth and the response to additional feeding is small. The response to feeding at different times of the year can be seen in *Figure 4* (over page). Increased feeding will result in a relatively large increase in wool growth in summer, less in other seasons. Beyond a certain point, however, there is little response.

Figure 4: Wool Growth in Response to Feeding Levels, at different times of the year, for Romney-type sheep *(Source: M.A.F.)*



Note: See also *Figure 1*, page A-54.

1.5.9 Wool Types/Weights for Budgeting Purposes

The main types of wool considered for budgeting purposes include fleece, necks, pieces, bellies and locks at main shearing and lambs wool, crutchings and deadwool at other times.

Where skirting is carried out at mainshearing (full length clip) the following proportions and weights are likely to occur:

	Category	*Greasy Weight (kg)*
Fleece	75 to 80 per cent	3.40 (75%)
Necks	up to 3 per cent	0.13 (3%)
1st Pieces	up to 9 per cent	0.40 (9%)
Bellies	up to 7 per cent	0.30 (7%)
Belly fribs	up to 1 per cent	0.04 (1%)
Locks and 2nd pieces	up to 5 per cent	0.23 (5%)
		4.50

Ewe crutchings amount to 0.2 to 0.3 kg, making a total clip of 4.75 kg per head per year for an average sheep.

Hoggets produce about 3.5 kg at hogget shear (1.0 to 1.5 kg as lambs, earlier).

Lambs crutchings weigh about 0.1 kg.

1.5.10 Breed/Fleece Characteristics

Source: Lincoln University Wool Manual 1990 (Wool Science Department).

	Category	Characteristic	Main Micron Range μm	Length Full Fleece (mm)
A1	Merino Fine Wool	Fine soft wools with well defined crimp, blocky staple, high bulk. Apparel wools - bright and white.	19-24	65 (for 18μm) 75 (for 23μm)
A2	Halfbred Corriedale Medium Wool	Wools of medium softness and fineness with well defined & flat to slightly tapered tip. Not quite as white and bright as Merinos. Mainly apparel and furnishings.	25-34	80 (for 26μm) 90 (for 28μm) 100 (for 32μm)
A3	Perendale *(see also A7)* Romney Coopworth Romcross Coarse Wool	N.Z.Romcross of predominantly Romney blood. Wools medium to coarse with more tapered staple tip. Slight creamy colour. Finer wool apparel furnishings, coarser wool carpets.	29-37 29-40 31-43	125 (for 31μm) 130 (for 33μm) 140 (for 35μm) 155 (for 37μm) 175 (for 41μm)
A4	Lincolns Leicesters Lustre Wool	Long, coarse, medium to high lustre wools. Low crimp and bulk, well defined staples, low medullation for diameter. Difficult to process, used for lustre products.	36-44	150-200 mm
A5	Drysdale Specialty Carpet Wool	Long, stapled, coarse heavily medullated wools. May contain high levels of kemp. Bright chalky white, very tapered tip. Used for carpets.	36-46	Usually Second Shear 90-140 mm
A6	Down and Down Cross Wool	A range of Down breeds. Wool short. Finer wools no defined staple crimp; coarser types poorly defined crimp. High bulk. Down cross longer more staple crimp. Wools may contain black fibre. Hosiery yarns, wool filled products.	24-31	40 (for 24μm) 75 (for 30μm)
A7	Cheviot, Cheviot Cross High bulk Perendale *(see also A3)*	The more Cheviot blood, the less staple crimp is defined. Fine medullated fibre. May be kempy. More Romney blood gives more defined staple crimp.	29-35	90 (for 29μm) 110 (for 35μm)

1.5.11 Further Wool Terms Explained

Sources: New Zealand Wool Board; Lincoln University Wool Manual 1990 (Wool Science Department).

Bulk:

Bulk is the filling capacity of wool, and is sometimes referred to as springiness or resistance. It is a measurement of the volume occupied by a given weight of wool, under a set load. High bulk wools generally lack well defined staple crimp but do possess a high level of individual fibre crimp along with a low lustre.

Low bulk wools (Lincoln and Leicesters) have a high lustre and silky glossy appearance.

Tables 7 and 8 are taken from Lincoln University's "Wool Manual 1990":

Table 7: Breed and Bulk

Breed	*Loose Wool Bulk cm^3/g*	*Breed*	*Loose Wool Bulk cm^3/g*
Down	34 - 38	Perendale	22 - 26
Downcross	34 - 37	Romney	20 - 24
Cheviot	31 - 35	Coopworth	19 - 23
Merino	29 - 33	Border Leicester	17 - 21
Halfbred	28 - 32	Lincoln/English Leicester	16 - 20
Corriedale	24 - 29		

Table 8: Wools are grouped into five grades for bulk as follows:

Bulk	*Bulk cm^3/g*
very high	>32.0
high	28.0 - 31.9
average	24.0 - 27.9
low	20.0 - 23.9
very low	<19.9

Lustre:

Highly lustrous wools, such as from Lincolns and Leicesters, have a glossy appearance and a silky touch. The lustre comes from the way the fibre reflects light. The wools are used in mohair blends for knitwear and hand knotted rugs. Like bulk, this is a characteristic determined by the breed. If present, the lustrous fleeces in a mob should be separated.

Medullation:

Some coarser wools, notably Drysdale, have large fairly empty cells forming a hollow core in the fibre. Medullated fibres are chalky in appearance because light is reflected from the inner walls. Heavily medullated fleeces should always be kept separate.

Moit:
See 'Vegetable Matter', below.

Oddments:
Oddments are the wools that are removed from fleeces on the board or at the wool table because they are either discolored or very much shorter. The proportion of oddments should be watched as a guide to skirting.

Proportions can vary considerably according to breed and wool type but guidelines are given on page A-62.

Vegetable Matter:
Vegetable matter is a collective term which covers all contaminants of vegetable origin. It is subdivided into: *Moit*, which material without hooks, such as hay, beech or manuka leaves; *Burr* - large seed pods of a hooked nature, such as clover burrs and bathhurst burr ; *Seed* - biddi-biddi,horehound etc.

Contamination of wool with vegetable matter is a problem of increasing importance. VM limits the processing of wool on machinery manufactured for processing synthetics, which are free of VM. All wool which is sold at auction in New Zealand is tested for VM content, but from the point of view of the manufacturer, the type of VM is often as important as the quantity.

1.5.12 Sampling and Testing of Wool

Source: Wool Manual 1990.

Sale Testing

Auction wool is sold on the basis of samples with grab and core samples being taken on arrival of the bales at the Woolstore.

All bales from a lot are grab-sampled by the broker and this sample is displayed in an open box for the exporters to examine in the woolstore. Core samples are also taken from all bales in the lot. These cores are tested for fibre fineness, yield and vegetable matter (and colour when required) according to International Wool Textile Organisation guidelines and the results of the tests are shown on a certificate which is displayed with the grab-sample.

Minimum grab sample per lot is 4 kg (except for 1 and 2 bale lots - 2kg). There are strict regulations governing the taking of grab and core samples.

The weight of cores taken shall be sufficient to provide five subsamples, each preferably 200 grams and not less than 150 grams.

Payment is based on the certified measured clean weight of wool.

Pre and post sale testing are carried out by:

New Zealand Wool Testing Authority,
P.O.Box 2065
Ahuriri
Napier

Or

SGS Wool Testing Services Division
P.O.Box 15062
Mirimar
Wellington.

An example of a pre-sale test certificate (NZWTA) is included over page containing the results of various tests done on a line of crossbred wool grown in Canterbury.

Certificate

NEW ZEALAND WOOL TESTING AUTHORITY LTD
Registered office at Napier.
Laboratories at Auckland, Wanganui, Napier, Wellington, Christchurch, Timaru, Dunedin & Invercargill

IWTO TEST CERTIFICATE

(IWTO-19/28)
FOR GREASY WOOL

DATE: 13/10/89
TEST No: 0-00294847-P9

Sale at: CHRISTCHURCH
On: 2/11
Broker: P.G.G. (CH)
Lot No: T 5083

Total Bales : 4

Gross Mass	:	561	Kg.
Declared Tare	:	4	Kg.
Nett Mass	:	557	Kg.

YIELD TEST RESULTS

Wool Base (2 Subsamples): 61.48 %

Vegetable Matter Base : 1.6 %
(Inc 0.0 % H.H. & Twigs)

FIBRE FINENESS (AIRFLOW)

Mean Fibre Diam. (2 Specs): 19.7 microns

ADDITIONAL INFORMATION

COLOUR (N.Z.S. 8707:1984)

X: 55.5 Y: 57.0 Z: 55.0 Y-Z: 2.0
Sampled 11/10/89

Average Clean Mass

Sch./Dry : 99 kg/bale

CALCULATED YIELDS

	%	Kg
1. IWTO S.W. @ 16%	74.9	417
2. IWTO SCH./DRY	70.8	394
3. IWTO S.W. @ 17%	75.5	421
4. IWTO C.W.C.	73.6	410
5. ASTM C.W.F.P.	71.5	398
6. JAP. C.S.Y.	72.4	403

NEW ZEALAND WOOL TESTING AUTHORITY LTD SEAL OF

5470

General Manager

M.F.MATTSON
Branch Manager

CERT No. 274311-C

This certificate is invalid if altered. The New Zealand Wool Testing Authority Ltd. will confirm the above data provided absolute proof of ownership is substantiated.

Fleece Testing

Fleece testing is carried out by the New Zealand Wool Testing Authority, SGS Wool Testing Service Division and also by the Lincoln University Wool Measurement Service.

Lincoln University provides both service and test results and advice on their use to ram breeders, to assist them and their clients to select the most suitable sires. However this service is not involved in commercial testing for sale lots.

Growers send samples of 60 to 100 grams taken from the midside (one full handspan from the backbone and over the last rib) to the service for measurements including the following: yield, fineness, colour and bulk. Other tests will be done on request.

For further information contact:

Wool Measurement Service,
Department of Wool Science,
Lincoln University,
Canterbury.

The Wool Research Organisation of New Zealand (WRONZ) is not involved in the testing of raw wool, but offers a very wide range of both raw wool and textile tests on wool and other fibres and also carries out Woolmark testing for the New Zealand Wool Board.

For further information contact:

Wool Research Organisation of New Zealand,
Private Bag,
Christchurch.

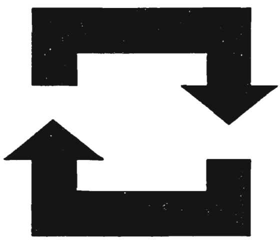
1.5.13 Common Wool Brands

Source: N.Z. Wool Board, 1990

Description	Abbreviation
Border Corriedale	BL/COR
Borderdale	BOR/D
Border Leicester	B/L
Border Merino	BL/MER
Backs	BKS
Bellies	BLS
Bellies & Pieces	B/P
Brands	BDS
Cotted	COT
Corriedale	COR
Crossbred	X
Crutchings	CRT
Cheviot	CVT
Coarse	CSE
Dead	DD
Dingy	DGY
Downcross	DNX
Drysdale	DRY
Early Shorn	E/S
English Leicester	E/L
Ewe	E
Eye Clips	E/C
Extra	Ex
Fine	F
Fleece	FLE
Hogget (woolly)	HOG
Hogget (shorn)	H
Lambs	LBS
Lambs' crutchings	L/CRT

Description	Abbreviation
Leicester	LEI
Lincoln	LCN
Locks	LOX
Medium	M
Merino	MER
Necks	NKS
Perendale	PER
Pieces	PCS
Ram	R
Reclassed by Co.	R/C
Romney	ROM
Ryeland	RYL
Sandy	SND
Second shear	2/S
Seedy	SDY
Scoured	SCD
Southdown	S/D
Stained	STD
Strong	STG
Suffolk	SUF
Super	SUP
Wether	W
Dags	DGS
First	1ST
Second	2ND
Third	3RD
Quarter	1/4
Half	1/2
Three quarters	3/4

Recyclers Brand: Recycled packs should carry the recyclers brand showing they meet the approved standard of repair:



1.6 <u>BEEF CATTLE</u>

1.6.1 Feed Requirements and Liveweight Charts of Beef Cattle

See pages A-10 to A-16 inclusive.

1.6.2 Breeding, Age and Physiological Information of Beef Cattle

See pages A-26 to A-29 inclusive.

1.6.3 Beef Cattle Health and Diseases

See pages A-30 to A-45 inclusive.

1.6.4 Beef Cattle 'Stock Unit' Measures

See pages A-100 to A-102 inclusive.

1.6.5 Beef Cattle Performance and Husbandry

See also Section 7 (pages G-6 and G-7), Stock Performance on New Zealand Farms.

Calving Percentage:

The average calving (weaning) percentage of a hill country breeding herd is 80% to 85%. However, in very rough country or under harsh climatic conditions it may fall as low as 60%. On the other hand, under good conditions and management, weaning percentages of 95% are attainable.

Weaning percentage is defined as the number of calves sold or retained at weaning, per hundred cows joined (or wintered).

Death Rate

A figure of 2 to 3% is acceptable for breeding cows, but this can rise up to 5 times in years with hard winters and late springs, which may also increase deaths in calves, from birth to weaning, from 3 to 4% to over 10%. Death rates are usually low (2 to 3%) after weaning.

Replacement Rate

A breeding cow on hill country will produce for 4 to 6 years on average before being replaced. Under good conditions this could be considerably longer (12 to 15 years).

The majority of heifers are mated to calve for the first time as 3 year olds but an increase in herd output can be achieved by mating heifers to calve one year earlier (as 2 year olds).

Bulls
Bulls are normally purchased as 2 year olds and used for 3 to 4 seasons.
Bulls are commonly used in a ratio of 1 to 30 or 40 cows although higher ratios (1:100) are satisfactory under intensive conditions. The mating period should not need to be longer than 63 days (3 cycles).

1.6.6 Dressing out Percentages of Beef Cattle

The most important single factor influencing the value of a store or slaughter beef animal is its carcass weight. Carcass weight can be estimated from liveweight when dressing out percentage is known.

$$\text{Carcass weight} = \text{liveweight} \times \frac{\text{dressing out \%}}{100}$$

Dressing out percentage is influenced by the liveweight and condition (fatness) of the animal. Heavier, fatter cattle have a higher (2 to 3%) dressing out percentage.

For example:

	Dressing Out %
Store cattle	45 - 48
Grass finished	50 - 53
Crop finished	52 - 55
Grain finished	54 - 58

1.7 DAIRY CATTLE

1.7.1 Feed Requirements and Liveweight Charts of Dairy Cattle

See pages A-17 to A-19 inclusive.

1.7.2 Breeding, Age and Physiological Information of Dairy Cattle

See pages A-26 to A-29 inclusive.

1.7.3 Dairy Cattle Health and Diseases

See pages A-30 to A-45 inclusive.

1.7.4 Dairy Cattle 'Stock Unit' Measures

See page A-101.

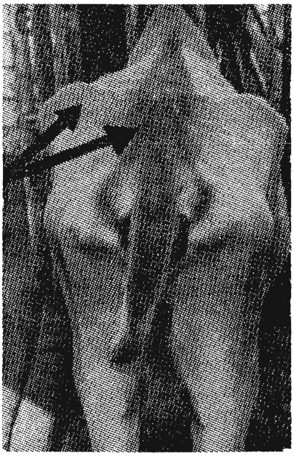
1.7.5 Dairy Cattle Performance on New Zealand Farms

See pages G-8 and G-9.

1.7.6 Dairy Cow "Condition Scoring"

See below, and on the following three pages, photographs of Jersey and Friesian cows with differing condition scores. A general recommendation is that dairy cows should be at a condition score of around 5.0 at calving.
Source: Jersey photographs from Department of Agriculture, Victoria.

The Indicators to Look For:

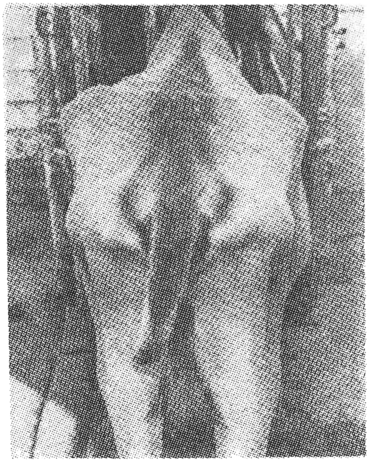


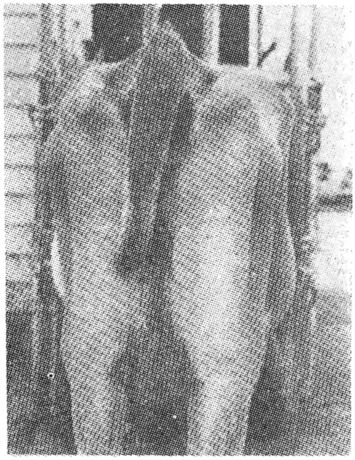
Amount of fat on backbone, hips and ribs

Amount of fat around base of tail and prominence of pin bones

Score 3

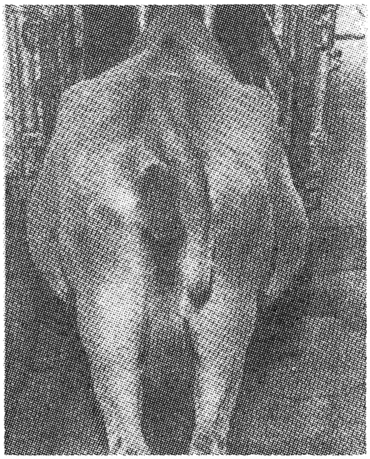
Area around base of tail sunken, hips and pin-bones sharply prominent:

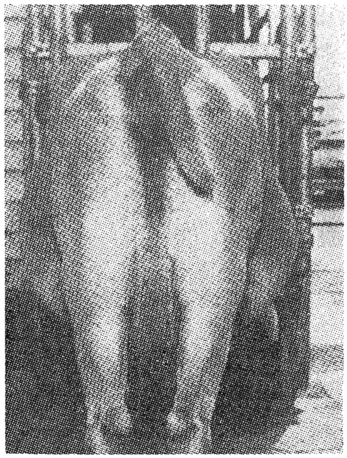




Score 5

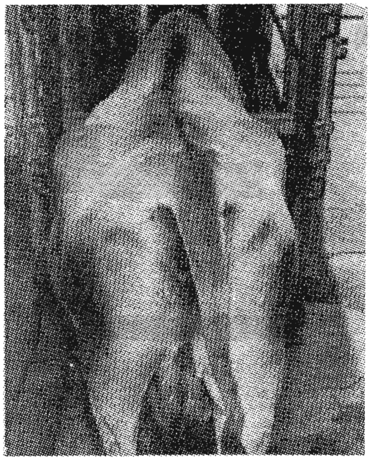
Area around base of tail partially filled out, hip and pin-bones not prominent:

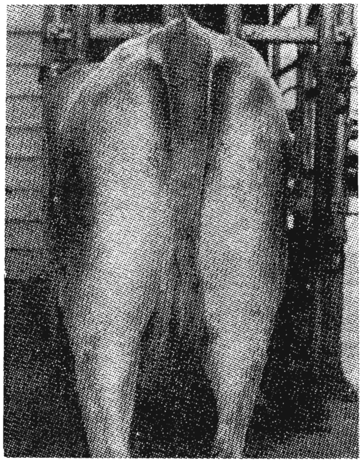




Score 7

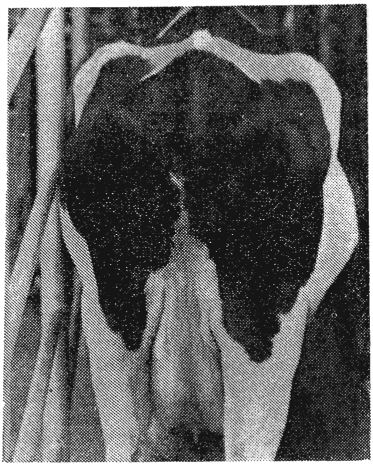
Area around base of tail well filled out, hip and pin-bones well covered:

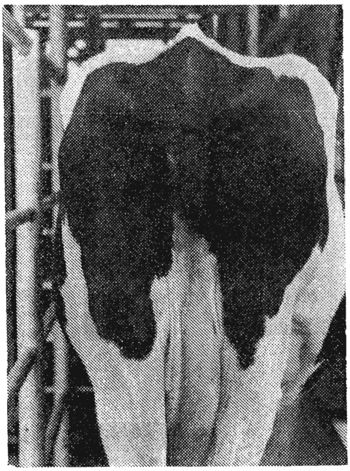




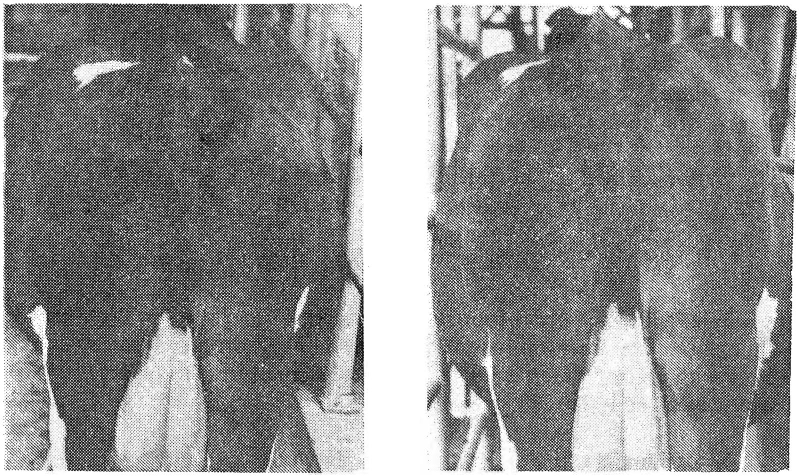
Score 3 to 3.5

Area around base of tail sunken, hips and pin-bones sharply prominent:

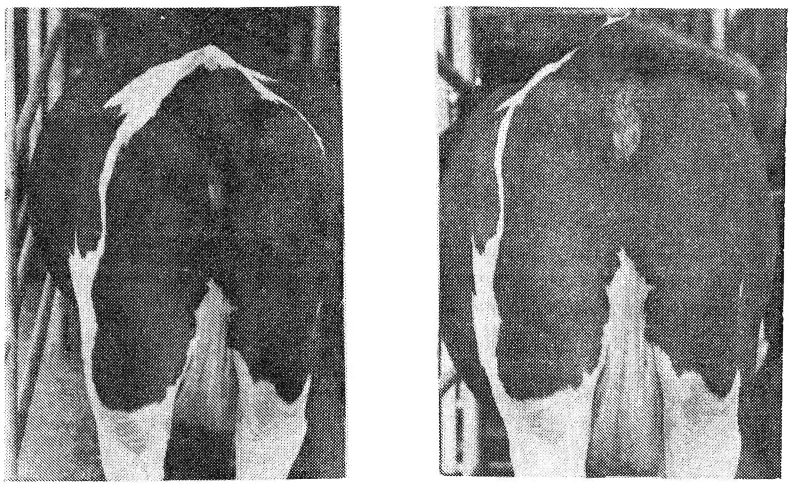




Score 5
Area around base of tail partially filled out, hip and pin-bones not prominent:



Score 7
Area around base of tail well filled out, hip and pin-bones well covered:



1.7.7 Estimation of Bodyweight of Dairy Heifers

The bodyweights of dairy heifers can be estimated by measuring either (a) around the chest girth (the circumference around the chest immediately behind the front legs); or (b) the height of the withers/shoulder (the highest point above the front legs).

One reference* gives estimates which apply to both Jersey and Friesian calves, as follows:

Bodyweight (kg)	Girth (metres)	Height (metres)
50	0.85 - 0.87	0.75 - 0.76
100	1.00 - 1.05	0.90 - 0.92

For heavier animals, figures from another source** are shown in the table below. Although they are intended for use with Friesian heifers#, the figures correspond closely with others* which apply to both Jerseys and Friesians (apart from a small discrepancy at the 100 to 120 kg level).

Bodyweight (kg)	Girth (metres)	Height (metres)
120	1.03	0.896
140	1.12	0.949
160	1.19	0.987
180	1.25	1.018
200	1.31	1.046
220	1.36	1.071
240	1.41	1.093
260	1.45	1.114
270	1.48	1.124
280	1.50	1.134
300	1.54	1.152
320	1.59	1.170
340	1.62	1.187

* *"Milk Production From Pasture" (1984) Holmes, C.W. and Wilson, G.F.*

** *"Estimating the Body-Weight of Friesian Heifers" (1980) Fulkerson, W.J., in Journal of Agriculture, Tasmania Vol. 51 No.4.*

\# *Friesian Heifers: Not pregnant, condition score about 4.0*

1.7.8 Calf Feeding (Cold Milk, Ad-Lib System):

(Source: M.A.F.)

The cold milk ad-lib system consists of feeding the milk to calves on demand. This is usually done in groups of 20 using a 200 litre drum with four teats. The calves have continuous access to the milk (i.e. "ad-lib").

Plastic drums (200 litre) are ideal, being light and easy to clean. Steel drums are also suitable (especially those with built-in plastic liners), provided they have no poisonous residues or lead paint.

Teats (three or four per drum) are mounted 750 to 850 mm above the ground on the drum itself - see *Figure 1*, below.

A weight is attached to the free end of each milk tube to keep it immersed.

Drums need to be inspected, stirred thoroughly and topped up daily. It is important to ensure that the drums do not run dry and that the feed tubes do not fall out of the teats.

New calves should first be kept in a pen, close to "training" drum, which should have extra teats. It is advisable to offer fresh warm milk during the training period.

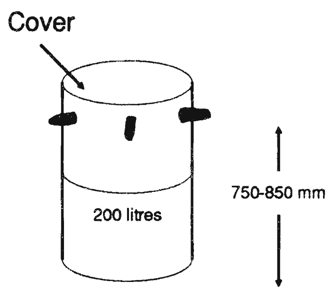


Figure 1: Vertical Feeding Drum

1.8 DEER

1.8.1 Feed Requirements and Liveweight Charts of Red Deer

See pages A-20, A-21 and *Section 1.8.5*, below.

1.8.2 Breeding and Physiological Information of Red Deer

See pages A-26 to A-28 inclusive.

1.8.3 Deer Health and Diseases

See pages A-30 to A-48, (particularly pages A-45 to A-48).

1.8.4 Deer Stock Unit Measures

See pages A-101, A-102.

1.8.5 Red Deer Growth and Development

(See also pages A-20, A-21).

Early Development:
At birth, fawns range from 6 to 10 kg, with stags being slightly heavier on average. Growth rates from birth to three months can be very rapid, with weaning weights of 50 kg being possible. It is necessary to provide high quality feed for the lactating hind and young fawns over the summer period. Growth rates of up to 200 g/day are attainable with good feeding in the period between weaning and winter. During winter an intake depression results in low growth rates before a period of very high growth rates over the subsequent spring/summer period.

Growth From 12 Months To Maturity:
The liveweight of deer at 16 months is critical. In hinds a weight of 65 kg at 15 months is important for mating; in stags a high liveweight at 15 to 16 months is important for slaughter for venison or retention as a future sire. Growth of the hind largely reflects the quantity and quality of feed on offer, whereas in stags feed intake declines during the first rut in March and April and the stag may lose weight. This pattern becomes more pronounced with age and at maturity the stag may lose up to 30 percent of its bodyweight over the rut and as a result enters the winter in poor condition. Consequently the winter feeding period is critical for stags.
There is a considerable variation in the mature liveweight of stags and hinds, with hinds averaging 90 kg and weighing up to 120 kg. Mature stags average 160 to 180 kg (pre-rut) with exceptional animals weighing up to 230 kg.

Productivity of Hinds:
Calving percentage averages 80 to 90%. Productive life can be up to 14 years.

1.8.6 Venison Production

Slaughter Deer:
These are farmed deer, usually 15 or 27 month stags (or cull animals) slaughtered in Deer Slaughter Premises (DSP). For this type of venison both ante and post mortem inspection are necessary.

Current grading for farmed red deer killed for one major company is as follows:

AP being all prime meat:

AP 1	> 85 kg	GR* < 14
AP 2	65.1 to 85 kg	GR < 14
AP 3	50.1 - 65 kg	GR < 12
AP 4	45.1 - 50 kg	GR < 12
AP 5	35.1 - 45 kg	GR < 10
AP 6	< 35 kg	GR < 10

AD being damaged meat.

AF being overfat meat:

AF1	GR* < 20 mm	Regardless
AF2	GR > 20 mm	of weight

* *The GR measurement is taken as the measure of tissue (both fat and meat) over the 12th rib, straight down from the hip bone i.e. the vertical drop.*

Kill Game:
This is shot feral deer that is inspected and/or packed for export in a Game Packing House (GPH). For this class of venison a post mortem inspection only is possible. Payout is usually on a per kilo basis for the whole carcass minus the head and feet, and is inclusive of by-products, including the skin.

See over page for dressing out percentage.

Carcass Dressing Out Percentage:
(Source: M.A.F.)

Proportion of liveweight as carcass; deer have a greater proportion of their liveweight as carcass than cattle or sheep:

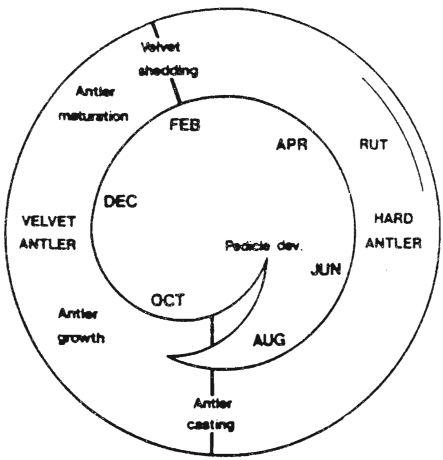
Carcass as a Proportion of Liveweight

	Liveweight (kg)	Carcass (kg)	Dressing (%)
Lambs -	35	15.7	45
Cattle -	400	220	55
Deer -	100	57	57
	140	81	58
	180	108	60
	200	120	60

1.8.7 Velvet Production

Velvet growth in red stags occurs over the spring/summer period and commencing with the casting of the hard antler or hard antler buttons in late winter/early spring. Antlers are normally harvested 65 days after casting (see *Figure 1*, below).

Figure 1: Cycle of Red Deer Antler Growth.
(Source: M.A.F.)



The weight and shape of the antler is considered when grading velvet. Grading differs between seasons and also between buyers but in general "Super A grade" antlers are those of top quality weighing over 3 kg (Super A1 & A2). "A grade" includes those with weights of between 1.8 and 3 kg (A1 & A2), and "B grade" those of under 1.8 kg (B1 & B2). Thinner, smaller antlers in this last weight category are classified as "C grade" and any broken or damaged velvet is graded "D".

Antler produced from yearlings (spiker) and regrowth velvet (taken subsequent to the first 60 day cut) is usually of low value.

Velvet Yields:
(Source: M.A.F.)
Although some exceptional stags give very high yields (4 to 5 kg per stag), average yields are much lower than this (see below):

Average Red Deer Velvet Antler Yields

Age (yrs)	**Weight (kg)**
2	1.1
3	1.6
4	1.9
5	2.2
Mature	2.4

Velvet antler production from ***wapiti*** is relatively higher than for red deer.
Wapiti are twice the size of red deer yet can produce four times as much velvet antler. Because of the larger size of wapiti velvet it can also command a premium at sale. Another advantage in velvet production from adult wapiti is the relatively lower feed maintenance requirement when compared to adult red deer. However, young wapiti stock do require proportionately as much feed as red deer for growth.

1.9 GOATS

1.9.1 Feed Requirements of Goats

See page A-22.

1.9.2 Breeding and Physiological Information of Goats

See pages A-26 to A-29 inclusive.

1.9.3 Goat Health and Diseases

See pages A-30 to A-45 inclusive.

1.9.4 Goat Stock Unit Measures

See page A-102.

1.9.5 Goat Fibre

Goat fibre is classed into a total of 22 different lines, but they can be broadly broken down to:

less than 19 microns	Cashmere
19 to 23 microns	Cashgora
23 to 25 microns	Fine mohair
25 to 35 microns	Coarse mohair

Mohair:

Mohair is noted for its high lustre, softness, and warmth relative to weight. It is used for premium quality textiles and fashion wear. The best mohair is produced by goats in their first 18 months of life. This is fine and soft and realises the highest price per kilogram.

Fineness is the most important quality of good mohair. Commercial mohair ranges from 10 to 25 cm in length and fineness range of 19 to 35 microns.

The angora goat should be covered with dense, soft, lustrous, kemp-free mohair, of good style and character. Kemp is a coarse straight medulated fibre.

Cashgora:

This is the fibre produced by mating an Angora buck over a Feral doe, it also includes some 'second cross' fibre. Cashgora is a down product and is derived from the secondary fibre layer of the goat. Its qualities include being a very fine fibre of 17 to 23 microns, and can be used as a 100% fibre in the manufacture of high class garments. Cashgora has some degree of lustre, and as such is distinctly different from Cashmere.

Cashmere:
Cashmere is a down product (short, soft and feels like cotton wool) and is derived from the secondary fibre layer of goats. It is the second finest animal fibre in the world, specifically in the range from 14 to 18 microns for the 'true' Cashmere with no lustre, although some processors have accepted fibre up to 20 microns with some lustre.

There is no specific breed of goat that cashmere is found on. A high percentage of N.Z. feral goats grow varying quantities of cashmere.

Cashmere goats have a double fleece (cashmere down and guard hair - 40 to 100 microns).
The fibre return is based on the actual yield of cashmere, not total fleece weight. Coloured fibre is discounted. There is a premium for finer grades.

Cashmere Breeding:
Cashmere can either be bred from feral to feral matings or from using the G4 (angora) route.

1. The G4 Concept:
   Two methods of approach:
   - G4 buck, i.e. Angora/Feral (1st cross) over feral does.
   - Feral bucks over G4 does and back-cross progeny with feral bucks.

   The advantage of the G4 route is that it will increase Cashmere weight and yield.
   The disadvantages are:
   - The micron diameter becomes coarser.
   - The spread of fibre diameters becomes larger.
   - There can be difficulties separating the down.

   In summary there is potential but anyone using the G4 route should be careful.
   It should also be appreciated that a number of animals will not be suitable for Cashmere breeding.

2. Feral Mating:
   Down weight and yields are low. However, the micron diameter is finer and the spread of micron diameters is more condensed.

Cashmere Production:
The average productivity of unselected feral does is approximately 50 g. The immediate objective to breed up to is 200 g.

Bucks and wethers produce more than does.

Kidding percentage varies from 80% to 160% depending on nutrition.

Cashmere Harvesting:
Cashmere is shed from the coarse guard hair coat in late winter and is not uniform over the body at any time. Shedding can be induced by stress.

Goats should be shorn at such a time so as to maximise fibre yield and quality and to avoid stress especially to kidding.

Shearing time must be related to kidding and this in turn will be dictated by local weather and feed conditions.

Fibre Handling:
Fine goat fibre is a quality product, poor handling dramatically cuts its value.

Shearing Preparation:

1. At least 3 weeks prior to shearing goats should be separated into colour categories:
   - White
   - White with coloured guard hairs (grey, black, tan)
   - Strongest colours (brown, black, dark grey)

   Separating mobs minimizes colour contamination.

2. Remove goats from scrub at the same time.
   Vegetation in the fleece reduces its value.

3. Clean down the shearing board.
   It may be necessary to vacuum to remove traces of coloured fibre which may contaminate white fleece (colour contamination of white fleece is not acceptable).

Shearing Order:

1. Shear the white ones first.
   Then the whites with tan or coloured guard hairs.
   Last the coloureds (blacks and browns)

2. Crossbred goats may not have any belly to be shorn, so a head holder can be used to speed up shearing.
   Angoras require full shearing.

Skirting:

1. Urine stain and dags should be skirted. They are colour contaminants.

2. All but low levels of seed or vegetable matter should also be skirted out.
   Contamination with these, down-grades fleeces.

3. Excessive hairy britch or back line can be removed in an effort to advance the fleece style.

1.10 PIGS

1.10.1 Nutrition of Pigs

See pages A-22 to A-25.

1.10.2 Breeding and Physiological Information of Pigs

See pages A-26 to A-29.

1.10.3 Pigs - Terms Explained

(Source: M.A.F.)

Entires: Uncastrated males not used for breeding, up to 6 months of age, or in carcass grading not exceeding 72.0 kg hot dressed weight.

Gilts: Young females, up to first farrowing. A mated gilt is sometimes referred to as a maiden sow.

Barrow: A male which has had its testicles surgically removed. Castration usually carried out in the first 3 weeks of life.

Rigs: Incorrectly castrated males, usually with one testicle left; or an entire with only one testicle.

Weaners: Young pigs weaned from the sow and weighing up to about 25 kg.

Stores: Pigs from 25 kg to the lightest slaughter weight of about 45 kg liveweight.

Porkers: Pigs used for the traditional fresh pork market, usually in the carcass weight range of 27.5 to 50 kg.

Baconers: Pigs used for the side bacon and ham processing trade. The preferred carcass range is 45.5 to 72.5 kg, although some companies take heavier (up to 79 kg) carcasses. For entire males the maximum is 72 kg.

Choppers: Entire males over 72 kg, culled sows, and boars, and other carcasses over 83 kg or considered unsuitable for bacon processing. Choppers are graded manufacturing and may only be used for small goods manufacture.

Farrowing index:
This is the number of litters farrowed by a sow or group of sows in a year, the latter being the average farrowing index for the herd. Calculated by dividing the total number of farrowings for a year by the average number of sows and mated gilts in the herd over the year.

Farrowing rate:
The number of sows/gilts farrowing as a percentage of the number mated.

Batch farrowing:

A situation where several sows or gilts farrow at the same time. This policy aids efficient use of accommodation, and disease control.

Multipliers: Producers who increase or multiply breeding stock for sale to commercial farms. This generally involves crossbreeding, with the sale of hybrid gilts (see over page).

Backfat: The layer of fat under the skin which covers the muscle over the back loin.

Feed conversion ratio (FCR):

Refers to the amount of meal (kg) or its equivalent required to produce 1 kg of liveweight gain during the growth period of pigs from weaning to slaughter.

Amino acids: *(see also pages A-22 to A-25).*

These are the base constituents of proteins, and are required in the correct proportions to maximise lean meat production in pigs. Ten amino acids are essential, those most commonly deficient in base cereals include Lysine, Threonine, Tryptophan, and Methionine. Protein supplements must be rich in these.

Digestible energy:

The measure of a feed's capacity to provide for body maintenance and growth is its available energy to the pig. Available digestible energy content is expressed as Megajoules (MJ)/kg. Cereals are usually the main energy source at 12.5 to 14.0 MJ/kg. Root crops or grass are relatively low, at 2.0 MJ/kg or less.

Growth Promoters:

Substances which are generally not essential nutrients, but when added to the diet in small quantities enhance performance. Included in the group are various antibiotics, copper, arsenicals, and hormones.

Dry sow stall:

A device similar to a farrowing crate in which non-lactating and pregnant sows are penned side by side in rows to prevent fighting and competition for feed.

Flat deck: A type of cage-like pen used for weaner pigs, it is raised above floor height with a partially or wholly slatted floor through which faeces and urine drop.

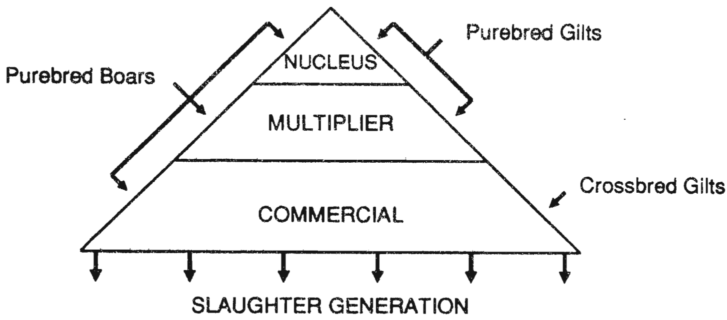
Creep: The term used to describe the area in a farrowing pen to which the piglets have access, but which the sow cannot enter. This area is usually artificially warmed by a heater and specially formulated feed is provided to the piglets.

1.10.4 Breeds and Breeding Policies

The common breeds used in New Zealand are Large White and Landrace (both are breeding stock).
Terminal sires used are Duroc and Hampshire. In outdoor situations crosses of the Duroc or Hampshire with the traditional breeds are used for breeding stock because of their hardiness.

Figure 1 shows the breeding policy for a commercial herd *(Source: Pigtech)*

Figure 1: Breeding Pyramid



Nucleus unit:	Purebreeding	LW boar x LW gilt LR boar x LR gilt
Multiplier Unit:	Crossbreeding	LW boar x LR gilt LR boar x LW gilt
Commercial Unit:	Backcrossing	LW boar x LW/LR gilt LR boar x LW/LR gilt
	Third Breed	D boar x LW/LR gilt H boar x LW/LR gilt

(All progeny from the commercial unit matings are slaughtered).

Key:
LW = Large White LR = Landrace D = Duroc H = Hampshire

1.10.5 Housing, Effluent and Water

(Source: Pigtech)

Housing

The following Table shows the minimum areas that should be allowed for when planning and designing pig housing for weaners through to slaughter weight stock.

Table 1: Recommended Minimum* Floor Areas:

Liveweight of pig	Minimum area allowance per pig		Total area (all layouts including fully slatted floors)
(kg)	Sleeping M^2	Dunging M^2	M^2 (square metres)
10	0.10	0.03	0.13
20	0.15	0.05	0.20
40	0.25	0.10	0.35
60	0.35	0.15	0.50
80	0.45	0.25	0.70
100	0.50	0.35	0.85
180	1.30	0.50	1.80

* *Note: These are minimum areas and are based on a stocking density which should not exceed 120 kg livweight of pig per square metre of total floor area. However, it should be noted that excessive space may lead to problems with cleanliness and ability to maintain room temperatures, so the figures given in the above table should not normally be exceeded by more than 25%.*

Temperature Regulation

This is a very important consideration, especially with younger stock. Piglets in a farrowing house need a separate area (still with access to the sow) where the temperature can be maintained at approximately 10^0 higher than the sow's area (see below; also page A-91).

Table 2: Example of Comfort Zones for Different Classes of Stock

Classes of Pig	Comfort Zone (^oC)
Suckling piglets	24 - 33
Weaners	20 - 28
Growers	16 - 22
Sows, gilts & boars	16 - 20

Effluent Disposal

Disposal of effluent is an extremely important aspect that has often not been given high priority when designing pig housing and determining optimum pig numbers. The following Table is a guide to the volume of effluent produced:

Table 3: Effluent Production

Class of Stock	Litres per animal per day Average	Comment
Grower (45 kg)	8.5	As excreted
Grower (45 kg)	25.0	Allowing for cleaning
Dry Sow (125 kg)	15.0	As excreted
Sow & Litter (170 kg)	40.8	As excreted
Weaner (18 kg)	3.1	As excreted

Water Requirements

The following table is a guide to the quantity of water required by pigs at various stages of growth:

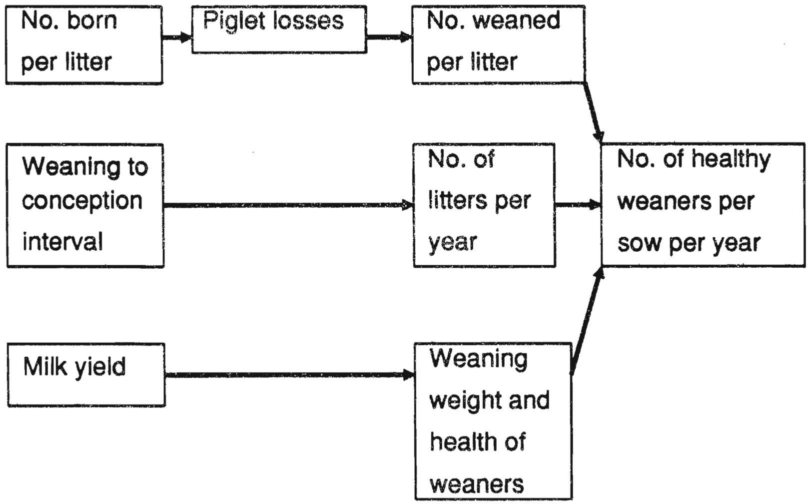
Table 4: Water Requirements for Various Classes of Pig

Class of Stock	Water Requirement (litres per day)
Weaners (10 - 25 kg)	1.0 - 2.5
Growers (25 - 40 kg)	2.5 - 4.0
Growers (40 - 60 kg)	4.0 - 6.0
Growers (60 - 90 kg)	6.0 - 9.0
Dry sows	8.0 - 10.0
Lactating sows	15.0 - 25.0

1.10.6 Factors Affecting Sow Output/Piglet Survival

Figure 2, below, summarises the factors which determine the number of piglets weaned per sow per year:

Figure 2: Components of Sow Output



Piglet Survival
Post-natal piglet mortality may be as great as 40%, average 15 to 20%. The major causes are:

Disease - mainly bacterial infections in the gut.
Poor environment - leading to disease and loss of vigour among newborn piglets.
Mechanical accidents - e.g. overlaying.
Starvation - associated with low birthweights and low viability.

Over half the losses occur within the first 2 to 3 days.

Table 5: Piglet Mortality on 21 New Zealand farms

	Average	Minimum	Maximum
Farm size -	114	30	300
Born alive per litter -	10.14	8.73	11.21
Weaned per litter -	8.7	6.5	9.73
Mortality (%) -	14.71	8.01	21.96
Average piglet loss per litter -	1.49	0.34	2.27

The risk of disease will be lower if farrowing quarters are kept clean and dry and diseased pigs are isolated. Caesarian births and rearing of piglets in sterile environments has been used to break disease cycles in some advanced piggeries. Absorption of adequate amounts of antibody from the sow's colostrum is important for disease-resistance development by the newborn piglet. Injecting the sow before farrowing with an E. Coli vaccine causes passive immunity for the piglet via colostrum.

The newborn piglets' thermo-regulatory mechanisms are poorly developed. In addition they have low amounts of sub-cutaneous fat and obtain little insulation from this or body hair. Cold piglets huddle up to the sow increasing the chance of being overlain. The temperature should be about 22 to 26°C in the creep area for the piglets and about 18°C for the sow (see also page A-88). The temperature for piglets can be slowly reduced, dependent on piglet weight and level of feeding. Initially 30°C in the creep area can be reduced to 28° to 29° after 1 week and 26° to 27° by 3 weeks and 23° to 24° after 5 weeks.

Starvation is a major cause of loss. Causes of starvation are:

Litter size larger than number of teats;
Teats drying off during suckling;
Growing piglets - less room at udder;
Mastitis and Agalactia in the sow.

In batch farrowing a cross fostering policy (evening up the litters, both piglet size and piglets per sow) should be practised. Smaller piglets will find it easier to obtain milk if grouped with piglets of their own size. Sows can be induced three to four days early in an attempt to have two or three sows farrowing at about the same time.

There may be times when there are more piglets than sows, due to death or prolonged Agalactia. A sow may be held back at weaning and surplus piglets fostered onto her. A sow reaches peak milk production three weeks after farrowing. If rearing piglets artifically from birth to 3 kg, liquid sow milk substitute should be fed with 3 to 6 kg milk based solid creep. Cow's colostrum, if available, can be used. The liquid diet should be fed 4 to 6 times daily (80 to 120 ml per piglet).

Table 6: Target Weaning Weights

Weaning Age (weeks)	Weaning Weight (kg)
3	5.5
4	7.0
5	9.0
6	11.5

(Source: Pigtech)

1.10.7 <u>Sow Condition</u>

The following is a guide to determining sow condition: *(see over page for target condition scores)*

Scoring Chart for Sow Condition

Score	1	2	3	4	5
General condition	Very thin	Thin	Good	Very Good	Fat
Feel	Hip bones & backbone prominent, easily felt.	Hip bones & backbone easily felt without palm pressure.	Hip bones & backbone only felt with firm palm pressure.	Hip bones & backbone cannot be felt.	Hip bones & backbone heavily covered with fat.
Visual appraisal	Hollow tailhead, prominent hip bones, ribs and backbone.	Backbone visible, flattened oval shape.	Hip bones, ribs and backbone not promin-ent. Rounded shape.	Very round-ed shape, tending to bulge.	very rotund with heavy deposits of fat on tailhead, back & over ribs.
Target	No sows in this category.	No more than 10% of weaned sows.	Target for weaned sows.	Target for farrowing sows.	Unnecessar-ily fat. No sows in this category.

Target Condition Scores:

	Score
At weaning	3.0
Mid-pregnancy	3.5
At farrowing	3.5-4.0
Herd average	3.5

1.10.8 Grading

(Source: Pigtech)

The carcass grade is determined by two major factors:

* Carcass weight.
* Backfat thickness (measurement taken off the backbone at the last rib) in millimetres.

Other factors taken into consideration include:

* Meat quality (colour and texture).
* Skin condition (pigmentation and blemishes).
* Sexual development (mammary development, and boars over 75 kg dead-weight).
* Veterinary aspects (abscesses, arthritis etc.).

Average carcass weights are as follows:
Porker - 36 to 41 kg average
Baconer - 45 to 75+ kg

1.11 NUTRITIVE VALUE OF STOCK FEEDS

1.11.1 Nutritive Value of Pastures, Conserved Feeds, Fodder Crops, Concentrates and By-Products

Note 1: The figures shown in the accompanying table (page A-94) are for maintenance feeding. Some variations between the relative values of feeds may occur depending on the productive purpose of the feed.
Note 2: See Section 1.11.2 for ***pig feeds.***
Note 3: See Section 1.1.1 for further references.

Definition of headings used in the table: (over page)

- **% D.M.** (Percentage Dry Matter, or Dry Matter Content of Feed):
  Dry Matter is the weight of feed less the water content. Supplements such as hay (dry matter content 85%) contain much less water than leafy winter pasture (dry matter content only 14%).

- **M.E. Concentration** (Metabolisable Energy Concentration):
  (Refer also to Section 1.1.1)
  The figures represent Mega Joules (M.J.) of Metabolisable Energy per kilogram of dry matter of feed. This measure compares feeds on the basis of their metabolisable energy as a proportion of dry matter. The M.E. Concentration of a feed may also be termed the M/D value.

- **kg of Feed Dry Matter:**
  This figure provides an estimate of the amount of feed required (kg D.M.) to provide the same quantity of M.E. as is contained in one kilogram (D.M.) of mixed length leafy ryegrass/white clover (which is assumed to contain 11.0 MJME). For example, (see over page), ***1.38 kg*** of *dry stalky (summer) pasture* is required to provide the same M.E. as ***1.00 kg*** of the pasture described above.

- **% Crude Protein** (Percentage of Crude Protein in 1 kilogram of Feed Dry Matter):
  For example, (see over page), green leafy lucerne contains 28% crude protein* per kilogram of dry matter. This value is termed 'crude' because all the N is not necessarily present as protein nitrogen.

* *28% Crude Protein: Expressed another way, this figure equates to 280 grams of crude protein per kg of D.M.*

Feed	% D.M.	M.E. Concentration (M/D value)	kg of Feed Dry Matter	% Crude Protein
Pasture - Ryegrass/White Clover:				
- "mixed length-leafy"	*15*	*11*	***1.00***	*25*
- spring, short leafy	15	11.8	0.93	24
- spring, mixed	15	11.2	0.98	20
- spring, rank	18	10.3	1.07	15
- summer, leafy	18-20	10.5	1.05	15
- summer, dry stalky	28	8	*1.38*	10
- autumn, leafy	15	10.8	1.02	25
- winter, autumn saved	17	10	1.10	20
- winter, leafy	14	11.2	0.98	26
Tama/Italian: See Greenfeeds (see page A-97)				
Pasture - Browntop dominant:				
- aut/wint/spring, leafy	15	11-11.5	0.98	20-22
- early summer	20	9	1.22	17
- mid summer	50	7	1.57	5
Pasture - Paspalum, leafy:	18	10.5	1.05	18
Lucerne:				
- green vegetative, (leafy)	15-20	11-12	0.96	28
- 10-20% flowering	22	9-10	1.16	22
Silages -				
: **Grass - direct cut or (wilted)**				
- early flowering	16-(30)	9-10	1.16	15-20
- late maturing	20-(30)	8-9	1.29	12-17
: **Lucerne**	20	8.5-10.5	1.16	16-20
: **Maize**- early dent or (mature)	30-(35)	10.3-10.5	1.06	8

Feed	% D.M.	M.E. Concentration (M/D value)	kg of Feed Dry Matter	% Crude Protein
Hays -				
: Pasture				
- Good quality (young leafy)	80-85	9	1.22	14
- Medium quality (mature)	85	8	1.38	11
- Poor quality (weathered)	85	7	1.57	8
: Lucerne	85	8-9.5	1.26	15-20
Straws:				
- Ryegrass	85	7.5-8.0	1.42	5-7
- Pea	85	7	1.57	8-9
- Oats, Barley	85	6.5-7.0	1.63	3-5
- Wheat	85	6	1.83	3-4
- Maize stover	85	7-8	1.47	3-6
Crops:				
- Turnips - tops	13	13.0-13.5	0.83	19
- bulb	9	12.5-13.0	0.86	13
- Rape	17	12	0.92	16
- Kale	15	11.5-12.5	0.92	15-20
- Green maize	22-24	9.5-11.0	1.07	9-10
- Maize - milk stage	25	10.3	1.07	8
- Swedes - tops	15	12.5-13.0	0.86	15
- bulb	10	12.5-13.0	0.86	12
- Sorghum, Sudax	17-23	9-10	1.16	10-18
- Fodder radish	11	11	1.00	17
- Lupins (sweet)	17-18	10.3	1.07	17
- Choumoellier - see kale				
- Potatoes	24	12.3	0.89	9

Feed	% D.M.	M.E. Concentration (M/D value)	kg of Feed Dry Matter	% Crude Protein
Greenfeeds:				
- Tama/Italian (leafy)	12-15	11-12	0.96	23-24
- Oats, Barley, Ryecorn	17-22	9.0-12.5	1.02	8-15
- Wheat	17-22	8.0-9.5	1.26	8-15
Concentrates:				
- Maize meal	86	13.9	0.79	10
- Wheat, Barley	86	12.5-13.5	0.85	11-13
- Bran (wheat)	86	9.6	1.16	17
- Oats	86	11.5	0.96	13
- Linseed cake	86	12	0.92	26-30
- Peas	86	13	0.85	25-30
- Pollard	86	12.2	0.89	18
- Lucerne meal	86	9.5-10.5	1.10	22
- Meat and bone meal	94	10.7	1.03	50

1.11.2 Nutritive Value of Pig Feeds

(Source: N.Z. Pork Board)

Average Nutrient Values of Commonly Available Feeds:

Feed	Crude Protein %	Fibre %	Fat %	D.E. MJ/kg	Lysine %	Methionine Cystine	Tryptophan %	Ca %	P %
Barley	10.3	3.5	1.9	12.75	0.30	0.35	0.17	0.03	0.35
Maize	8.7	2.0	4.0	14.25	0.20	0.30	0.08	0.02	0.30
Wheat	12.0	2.5	1.8	14.10	0.30	0.28	0.12	0.05	0.40
Pollard	15.0	8.5	4.0	10.15	0.55	0.35	0.33	0.13	1.0
Bran	13.5	11.5	3.0	9.2	0.49	0.30	0.25	0.13	1.0
Tallow			99.4	29.33					
Meatmeal	55.6	1.0	12.7	12.54	3.0	1.4	1.3	7.5	4.0
Meat and Bone meal	45.52	2.0	9.0	12.0	2.4	1.2	0.19	10.5	5.2
Dried Blood Meal	80.00	1.00	1.4	11.3	7.5	2.2	1.1	0.28	0.22
Skimmed Milk Powder	33.5		0.9	14.54	2.8	1.3	0.5	1.25	1.0

Feed	Crude Protein %	Fibre %	Fat %	D.E. MJ/kg	Lysine %	Methionine Cystine	Tryptophan %	Ca %	P %
Buttermilk Powder	30.0		8.0	14.54	2.8	1.2	0.50	1.3	0.9
Fish meal	65.0	1.0	7.0	13.37	6.0	2.5	0.9	4.5	2.0
Uni-white lupins	32.0	15.0	5.0	12.75	1.6	0.64	0.25	0.07	0.48
Pea meal	22.0	6.0	2.0	14.63	1.6	0.45	0.22	0.17	0.42
Whey powder	13.8		0.6	13.33	1.1	0.50	0.20	0.87	0.79
Dried lucerne	19.5	16.0		8.15	0.9	0.45	0.5	1.43	0.25
Ground limestone								34.00	0.20
Steamed bone flour								24.00	12.00
D. calcium phosphate								26.00	18.00
Rock phosphate								34.00	14.00

1.12 STOCK UNIT CONVERSIONS

1.12.1 Introduction

The stock unit (s.u.) conversion relates the energy requirements* of various classes of stock to the requirements of one breeding ewe (55 kg) producing one lamb per annum.

Stock units are conventionally calculated for winter tally at 30 June and 1 July each year.

Stock unit measures used in N.Z. may differ slightly between agricultural organisations.

* *total yearly energy requirements*

1.12.2 M.A.F Stock Unit Figures

Source: Cornforth and Sinclair, (1984) - see reference [20] on page B-65.

Table 1: Stock unit measurements for EWES, based on ewe weight and percent lambs weaned.
(See Table 3 for other sheep).

Ewe weight at mating (kg)	Percent lambs weaned								
	70%	80%	90%	100%	110%	120%	130%	140%	150%
35 kg	0.65	0.70	0.75						
40 kg	0.70	0.75	0.80	0.85	0.90				
45 kg	0.75	0.80	0.85	0.90	0.95				
50 kg	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15	
55 kg		0.90	0.95	**1.00**	1.05	1.10	1.15	1.20	1.25
60 kg			1.00	1.05	1.10	1.15	1.20	1.25	1.30
65 kg				1.10	1.15	1.20	1.25	1.30	1.35
70 kg				1.15	1.20	1.25	1.30	1.35	1.40
75 kg				1.20	1.25	1.30	1.35	1.40	1.45

Table 2: Stock unit measurements for DAIRY COWS, based on cow weight and milkfat production. (Data from Bryant, M.A.F.)

Cow Liveweight (kg)	Milkfat Yield (kg)						
	100kg	120kg	140kg	160kg	180kg	200kg	220kg
250 kg	4.6	5.1	5.5	6.0	6.4		
300 kg	4.9	5.4	5.8	6.3	6.7	7.2	
350 kg	5.2	5.6	6.1	6.5	7.0	7.4	
400 kg	5.5	5.9	6.4	6.8	7.3	7.7	8.2
450 kg	5.8	6.2	6.7	7.1	7.5	8.0	8.4
500 kg		6.5	6.9	7.4	7.8	8.3	8.7
550 kg			7.2	7.7	8.1	8.6	9.0

Table 3: Sheep, Cattle & Deer (including young stock)

Ewe (see Table 1)	
Wether	0.7
Rams	1.0
Hogget 30 kg, slow growth rate	0.7
40 kg, medium growth rate	1.0
50 kg, rapid growth rate	1.2
(pre-winter hogget weights)	
Beef cow* 350 kg, 68% calves weaned	3.7
400 kg, 83% calves weaned	4.4
450 kg, 88% calves weaned	5.3
500 kg, 90% calves weaned	6.3
Beef weaners* 135 - 270 kg	3.5
Beef*, 200-400 kg, slow growing	3.7
200-465 kg, rapid growing	4.6
350-500 kg,	4.7
Bull* 500 kg	6.0
Jersey yearling 0-12 months	1.7
Friesian yearling 0-12 months	1.9
Jersey heifer	3.0
Friesian heifer	3.4
Red deer - Weaning to 15 months - Males	1.4
- Females	1.2
- 15 to 27 months - Males	1.8
- Females	1.8
- Adults - Males	2.1
- Females	1.9
Fallow deer - use half of red deer values	

(Data from J.D.J Scott and J.L. Adam, M.A.F.).

* See also *Section 1.12.3*, over page.

1.12.3 Further Stock Unit Conversions (Common Usage)

Beef Cattle

	s.u.
Heifer calf, autumn-born	2.0
Rising 1 year heifer	3.5
Rising 2 year heifer, empty	4.5
Rising 2 year heifer, in-calf	6.0
Rising 3 year heifer, in-calf	6.0
Beef breeding cow	6.0
Steer or bull calf, autumn-born	2.0
Rising 1 year steer/bull	4.0
Rising 2 year steer	5.0
Rising 3 year steer, and older	5.5
Rising 2 year bull, and older	5.5
Nurse cow, multiple-suckled	up to 8.0

Horse - 7.0 s.u.

Goat

Angora does - 0.8 to 1.1 s.u. depending on liveweight and kidding rate.
Feral Does - 0.6 to 0.9 s.u. depending on liveweight and kidding rate.
Feral Wethers/Bucks - 0.5 s.u.

Milking Goats - up to 2.5 s.u.

Note: Because goats tend to complement rather than compete with conventional stock for feed, and because of different feed requirements of ferals versus purebreds, stock unit values may differ from those shown.

SECTION 2

PASTURES

Contributors

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Section 2.12 was revised in 1986 with the assistance of the Plant Science Department.

2.1 BACKGROUND INFORMATION ON N.Z. PASTURES

2.1.1 General

The information included in Sections 2.1 to 2.5 (inclusive) is designed to give readers an introduction to the features of a number of new or popular pasture plants. However, as every farm and district has its own unique set of pasture requirements and problems, farmers planning to renovate pasture should seek advice from local pasture specialists. Further information can also be found in various texts such as "Pastures, Their Ecology and Management" (Langer, 1990), N.Z. Grasslands Association Proceedings, M.A.F. Aglinks and various commercial publications. (Note: Refer also to reference list at the end of this section).

2.1.2 Role of Perennial Ryegrass

Ryegrass has played a major role on pastoral farms in New Zealand for decades. It has displayed an ability to establish quickly and produce well over a wide range of regions, environments and management systems. Other grass species are generally more costly and difficult to establish, and in some cases do not persist unless they are carefully managed.

However for dryland/droughty situations, ryegrass has demonstrated limitations due to relatively shallow roots, susceptibility to attack from grass grub and argentine stem weevil, and relatively poor summer growth and feed quality. Recent 'high endophyte' cultivars have provided better persistence and growth through drought conditions, but unfortunately this has often been accompanied by stock health difficulties ("ryegrass staggers") and low clover content in the sward. Some researchers and farmers have demonstrated mixed feelings towards the continued reliance on ryegrass, and consequently have been keen to see the introduction of other promising species into the sward.

2.1.3 Establishment of "New/Alternative" Grasses

(Note: See also Section 2.2)

Grasses other than ryegrasses tend to be less tolerant of low soil temperatures and moisture levels (during establishment), and therefore where autumn sowing is practised, it is important that this be in <u>early</u> autumn, and that in dry districts, a summer fallow be used to conserve soil moisture for these sowings[1]. On cultivated seed beds, early autumn establishment of "Matua" prairie grass and "Maru" phalaris can be almost as rapid as for ryegrass, while other grasses such as "Wana" cocksfoot are slower. The problem of slow establishment is much more severe when oversowing on uncultivated hills[2]. For South Island dairying districts, it has been noted that most species other than ryegrass do best when spring sown[3]. Farmers have also been advised to be wary of the vigour of ryegrass seedlings when sowing mixtures containing other grasses, and to reduce the proportion of ryegrass seed accordingly[3] (see 2.2.1 - Perennial Ryegrass).

As detailed in Section 2.2 (page B-4), many of the "alternative" grasses must receive careful grazing management during the first 12 months (overgrazing must be avoided).

2.1.4 Establishment of "New" Clover Cultivars

(Note: See also section 2.3)
There is considerable difficulty in establishing 'new' clover cultivars by oversowing into old pasture because surviving stolons of resident white clover plants and germinating hard seed tend to dominate after oversowing[4]. Full cultivation is therefore a more successful technique for the introduction of new cultivars compared with spraying and overdrilling[3].

When clovers are establishing, frequent grazing is required during winter and early spring to ensure the young plants receive adequate light, especially when sown with ryegrasses[5].

2.2 GRASS VARIETIES - CHARACTERISTICS AND ESTABLISHMENT

2.2.1 Ryegrasses

Perennial or Long Rotation/Term Ryegrasses

(Note: See also Sections 2.1.2. & 2.1.3)
A variety of cultivars is available, with most of the newer types being advertised as containing high levels of "endophyte" in the seed, which will confer on the grass plants protection from argentine stem weevil, and hence better persistence and more summer/autumn production from the pasture. Refer to page B-5, "Endophyte Test for Ryegrasses". Note that only fresh seed can be assured of having high endophyte levels. Also note that "Grasslands Super Nui" (not included in the table) is the same grass as "Grasslands Nui", but with high endophyte level (certified to be more than 70% in seed at time of testing). Other recent releases are "Embassy", "Marathon" and "Grasslands Marsden" (which is described as being a high endophyte replacement for "Ariki").

The sowing rate normally recommended for perennial ryegrasses *is approximately 18 to 22 kg/ha* (plus clovers) - heavier if the seed is to be broadcast, and lower if other grasses are to be included in the mix. Ryegrass seedlings can cause considerable suppression of other slower establishing grasses when sown in high fertility soils. One recommendation is that seeding rates of ryegrasses should be reduced to 6 to 12 kg/ha, when sown with slower establishing companion grasses such as cocksfoot[6].

Short Rotation/Term Ryegrasses

(Note: See also Section 3, Forage Crops)
Varieties include:
"Concord", "Exalta", "Greenstone", "Manawa" (H1), "Moata"(which is an "Italian" type - replacing Paroa), "Progrow" and "Tama".

Short rotation ryegrasses are characterised by higher winter production than perennial ryegrasses, and by having good palatability and quality characteristics. Commercially available cultivars range from annuals such as "Tama" to longer term hybrid grasses such as "Manawa" (H1) and "Greenstone". They are often sown as specialist short term pastures for high quality winter and spring forage (*refer to Section 3 for sowing information*). Also they have often been incorporated into 'permanent' pastures (either as a component of the seed mix at approx. 4 to 8 kg/ha or by overdrilling into established pasture) to improve the late winter and spring production. However, some researchers strongly advise against this practice, arguing that the susceptibility of short rotation ryegrasses to argentine stem weevil attack, will eventually lead to the weevils also attacking the companion perennial ryegrass in the pasture[10]. Refer also to the table below, under "Italian and Hybrid ryegrasses".

Endophyte Test for Ryegrasses (Ryegrass endophyte *Acremonium lolii*)

(Note A: See also Section 2.2.8 - Susceptibility of Grasses to A.S.W. attack.)

(Note B: This section on Endophyte Tests is adapted from a paper presented by Lucas and Fraser at the 1989 Animal Industries Workshop, Lincoln College - reference details are given at the end of Section 2).

The results of endophyte tests have only short term validity because endophyte level declines under normal seed storage conditions. Only fresh seeds of high endophyte lines can be guaranteed to have high endophyte. If the seed is stored for about 18 months endophyte status can drop to unacceptable levels. Seed stored in a cool store (5°C) will retain its Endophyte fungus for much longer than 18 months. This means that to ensure perennial ryegrass contains high levels of endophyte a farmer should buy only new seed from a recently released variety. Otherwise a recent endophyte test is required.

Endophte Tests

Endophyte Incidence in Fresh Seed of Commercial Cultivars (adapted from Thom, Prestidge & Barker, 1987)

	Percentage of Seed Infected with Endophyte (on average)	Range of Results
Perennial Ryegrasses		
"Nui"	39 %	10-86 %
"Ellet"	80 %	65-99 %
"Yatsyn"	90 %	80-99 %
"Droughtmaster"	80 %	70-90 %
Uncertified "Permanent Pasture"	36 %	4-90 %
"Ruanui"*	5 %	0-10 %
"Grasslands Marsden"	high	
Italian and Hybrid Ryegrasses		
Italian ryegrasses (*Lolium multiflorum*) and short - rotation ryegrasses (*Lolium hybridum*) such as "Moata", "Manawa" and "Greenstone" have little or no infection with endophyte (*Acremonium lolii*). They are therefore very prone to attack from Argentine Stem Weevil.		

* Latch & Christenson, 1982.

2.2.2 Cocksfoot

(Note: See also section 2.1.3).
'New' cocksfoot varieties include "Wana", "Suborto", and "Kara".

"Wana"

Suitable for sheep (and cattle) grazing. More active than ryegrass over the summer to winter period. Once established, is very drought tolerant and can withstand attack by grass grub and argentine stem weevil. Good quality feed. Has good characteristics for dry hill country and is tolerant of moderate/low soil fertility.

Warm, moist soil conditions required for establishment. Seedlings are slow to develop and are inhibited by competition from other species. *Seeding rates approx. 10-12 kg/ha (with clover) or 4-6 kg in grass mix* (ryegrass content must be restricted - see 2.2.1, perennial ryegrass). Reputedly sensitive to seed depth (optimum 1 to 2 cm). Nitrogen application and lax grazing helps establishment. The first grazing should be brief and preferably by young stock, as seedlings are easily uprooted. Full growth potential often not seen until 1 to 2 years after sowing.

"Suborto"

Suitable for cattle grazing. Reputed better establishment than Wana in difficult conditions. Also reputed better cool season growth (cold/frost tolerant) and strong late summer growth. Will withstand moderate grazing pressure.

"Kara"

Suitable for cattle grazing. Improved cool season growth. Excellent seedling vigour. Suited to rotational grazing.

2.2.3 Prairie Grass ("Matua")

(Note: See also Section 2.1.3).
Prairie grass is a good producer of high quality winter feed, and can also produce well in other seasons if grazed correctly and given adequate fertiliser[8]. Goes to "head" from October to February, but remains palatable throughout. Suitable for silage and hay production.
Can withstand drought and recover well in autumn, with good management. More tolerant of grassgrub than ryegrass. Requires free-draining, medium to high fertility soil.
Does not tolerate set stocking; requires long spelling periods for survival. Suited to dairying where grazing is lax and rotational. Sensitive to treading; should not be grazed when soil is wet or frosty; winter grazing should probably be kept to a minimum.
Pasture life approx. 7 years maximum; most self sown seedlings do not survive after their first grazing[3].
Has a high requirement for nitrogen, therefore vigorous clovers are required (see page B-7). Nitrogen fertiliser can be used to boost production (good response in late winter and early spring) and extend the life of the stand. Prairie grass is reputed to contain low levels of elements, such as magnesium and iodine[9].

Spring or autumn sowings must be early, into warm, moist soil[1]. Seedlings will grow vigorously in ideal conditions, but careful grazing management is required during the first 12 months. *Drill at 25 to 30 kg/ha (B/C 40 kg/ha)*, with large leaf type clovers such as "Pitau", "Kopu" or "Pawera", which are better able to withstand the tendency of "Matua" to smother - see 2.3 (page B-9). Certified seed harvested from stands free of headsmut should be used, but a thorough fungicide treatment is also recommended[6]. Prairie grass is sometimes sown with low seeding rates of other, more persistent, grasses.

2.2.4 Tall Fescue

(Note: See also section 2.1.3).
Cultivars include "Roa", "Au Triumph", "Cajun" (a re-selection of "Au Triumph") and "Johnson".

Tall Fescue is tolerant of a wide range of soil conditions and is suitable as a perennial grass base in difficult enviroments [8]. Once established, tall fescue plants can withstand dry soil conditions and tolerate grass grub and other pests [7]. Production is reputed to be better than ryegrass during summer and autumn (growing better into and out of droughts, maintaining green leaf). Feed quality is retained through frosts, and plants can withstand winter trampling.

Tall fescue grows well in medium/good fertility soils, and responds to nitrogen. Best suited to a lax rotational grazing system, but should not be allowed to grow rank as it becomes unpalatable[7].

Tall fescue is very slow to establish, and should not be sown with ryegrasses. *Sowing rate approx. 20 to 25 kg/ha* plus clover (legumes do well with fescue). Cocksfoot and/or Phalaris may be suitable as companions, with fescue seed rate reduced to 10 to 15 kg/ha. Seed should be fungicide treated. Sown either in spring or early autumn (soil warm and moist). In Canterbury, for example, autumn sowings should preferably be in February and certainly no later than mid-March[3]. Grazing should not take place too early, and must be light and quick, as overgrazing and plant pulling can occur in the first year[1]. Initial production is often low, although nitrogen usage may improve this.

2.2.5 Phalaris ("Maru")

(Note: See also section 2.1.3).
Excellent cool season production (autumn to late spring), but semi-dormant in dry summer conditions, and therefore is an ideal companion with summer active species such as lucerne, red clover or chicory[3]. However, under irrigation, it can produce well in the summer and autumn. Once established it can withstand severe droughts and is very persistent, able to tolerate hard grazing and trampling. However production is best if grazing is lax[6]. Resistant to grass grub and all N.Z. pasture pests[7].

Produces well on fertile soils, and is very responsive to nitrogen in autumn and spring. Once established, it is best kept in a leafy state, as the palatability declines when mature. Careful management is required to prevent clover suppression[8].

In summer dry districts phalaris should be sown in the autumn. *Seeding rate approx. 3 to 5 kg/ha in a mix* with other pasture species such as those mentioned above, or with cocksfoot and/or tall fescue. Seedlings are slow to establish; lax grazing is required. Suffers from competition by ryegrass at the seedling stage[6].

Pure phalaris pastures (6 to 10 kg/ha plus clover) have not usually been sown in N.Z. because of a reputation for causing phalaris staggers in sheep, particularly as a result of grazing for long periods on fresh autumn/early winter growth. Pasture specialists have recommended taking the 'cautious approach' by sowing phalaris with at least one other grass, to "dilute" the possible toxic effects[3].

2.2.6 Timothy ("Kahu")

(Note: See also section 2.1.3).
A possible component of dairy pastures, particularly in moist environments. Good warm season growth, good palatability for both grazing and hay production.

2.2.7 Other Grasses Available for Pasture Improvement:

Other grasses available commercially include - Yorkshire fog, Paspalum, Grazing brome (related to prairie grass) and Brown top.
(Note: See also Section 2.5.3).

2.2.8 Susceptibility of Grass Varieties to Argentine Stem Weevil Attack[16]

Susceptibility to Attack:	Susceptibility of Young Plants (first 12 months)	Susceptibility of Mature Plants (plants older than 12 months)
Very High	Short Rotation Ryegrasses	Short Rotation Ryegrasses
High	- Low endophyte lines of perennial ryegrasses. - Cocksfoot. - Timothy	Low endophyte lines of perennial ryegrasses.
Medium	- Prairie Grass - Tall fescue - Phalaris	- Timothy - Cocksfoot
Low	High endophyte lines of perennial ryegrasses.	- High endophyte lines of perennial ryegrasses. - Prairie grass. - Tall Fescue. - Phalaris.

2.3 DETAIL ON NEW/POPULAR CLOVERS

2.3.1 White Clover

(Note: See also Section 2.1.4)
White clover varieties include "Tahora", "Pitau", "Kopu" and "Huia".

"Tahora"
Produces well in heavily grazed hill country of medium/low soil fertility and adequate rainfall[6]. It is reputedly the best white clover to use where sheep are intensively grazed or set stocked, and has been recommended for a wide range of situations, including drought-prone downlands and easy hill country[13].
Sowing rate approximately 3 kg/ha with grasses.

"Pitau"
Suited for cattle/dairy grazing in medium/high fertility lowland pastures, particularly in the North Island. Prefers moderate/lax grazing management. Has improved cool season production (compared to Huia, in North Island). However it is slower to establish and requires careful grazing management initially.

"Kopu"
Suited for rotationally grazed cattle/dairy pastures, with good winter production in warmer climates, greater overall productivity and nitrogen fixation than "Huia" (see below). As with "Pitau", "Kopu" is reputed to perform well in higher fertility lowland pastures.

"Huia"
This older cultivar was first released in 1930 and has been used extensively throughout New Zealand.

2.3.2 Red Clover

(Note: See also Section 2.1.4)
Red clover varieties include "Pawera", "Colenso", "Hamua" and "Turoa".

"Pawera"
"Pawera" is a good producer of quality herbage (particularly over summer), tolerant of dry conditions, resistant to pests and diseases and having improved persistence, compared to older varieties[6]. Requires reasonable soil fertility, and is well suited to special purpose pasture mixtures, such as with "Matua" prairie grass or "Italian" ryegrasses; and produces excellent quality hay[9]. *Sowing rate approx. 4 to 6 kg/ha,* when sown with grass. Possible problems with bloat and high oestrogen levels[11].

"Colenso"
An early flowering red clover with superior autumn and winter production compared to "Hamua"/cow grass[12]. The first red clover released in N.Z. with a lower level of oestrogen, a factor which can affect ewe fertility. Reputed to have improved drought tolerance and persistence.

"Hamua" ("Cowgrass") and **"Turoa"** are older cultivars, once in common use in New Zealand. "Hamua" is a short lived clover, while "Turoa" is more persistent and tolerant of drier conditions.

2.3.3 Subterranean Clover

"Tallarook" and "Mt Barker" have commonly been recommended as additions to pasture mixes (approximately 3 to 5 kg/ha) for summer-dry hill country[14]. Other cultivars include "Trikkala" and "Karidale".

2.3.4 Other Clovers: Caucasian, strawberry, zigzag, alsike.

2.4 LUCERNE AND OTHER PASTURE LEGUMES

2.4.1 Lucerne Varieties Available in N.Z.[17]

Varieties	Blue Green Aphid	Pea Aphid	Spotted Aphid	Bacterial Wilt	Stem Nematode	Phytophthora	Verticillium Wilt	Leaf Diseases	Fusarium Wilt	Winter Dormancy	Source
CRD Otaio	R	R	R	R	R	R	--	S	--	SA	Agricomm*
Baron	R	R	R	R	S	R	--	--	R	A	Challenge
Grasslands Oranga	R	R	R	R	S	S	--	MR	--	SD	Public
WL320	(MR)	(MR)	(R)	(R)	(MR)	(R)	(MR)	--	(R)	SD	Challenge
WL311	SR	R	R	R	S	S	(SR)	MR	--	SD	Hodders
Washoe	S	MR	R	R	R	R	(S)	S	S	SD	Public**
PR555	(S)	(HR)	(HR)	(HR)	(S)	(S)	(S)	--	(MR)	SD	Genetic Tech.
AS13R+	S	SR	R	R	R	HR	--	S	HR	VA	PGG
PR5444	(S)	(S)	(HR)	(MR)	(SR)	(SR)	(HR)	--	(HR)	D	Genetic Tech.
Saranac	S	MR	S	R	S	S	(SR)	MR	--	SD	Public**
Wairau	S	S	S	S	S	S	(SR)	S	--	SD	Public

HR = Highly Resistant; **R** = Resistant; **MR** = Moderately Resistant; **SR** = Slightly Resistant.
-- = Not Tested; ( ) = provisional; **D** = Dormant; **SD** = Semi-Dormant; **SA** = Slightly Active;
A = Winter Active; **VA** = Very Winter Active.

* Becoming Available 1990; ** Becoming unobtainable.

2.4.2 Other Pasture Legumes:

(Note: See also Section 2.6.3, Table 3)

Lotus ("Maku")

Also :
Crown vetch, birdsfoot trefoil (lotus corniculatus), narrow leaf treefoil, sainfoin, sulla, serradella (annual).

2.5 HERBS FOR PASTURES

2.5.1 Chicory ("Puna")

"Puna" Chicory produces large quantities of high quality herbage over summer, but it is dormant in winter. A drought tolerant perennial with no apparent pest or disease problems[3]. Prefers fertile, well drained soils and responds to nitrogen fertiliser. A rotational grazing system is preferred. However, heavy winter treading should be avoided, as this may damage the crown of the plant and allow entry of disease. Chicory should be sown with a clover, or in a grass and clover mix, possibly with winter active grasses such as prairie grass or phalaris. May be grown purely as a summer forage crop (reputed to have high palatability and to promote rapid liveweight gain in stock), but requires high fertility.

Sowing rate approximately 3 to 5 kg/ha (plus clover), or 0.5 to 1.0 kg/ha in a pasture mix. Spring sowing is preferred, although early autumn has been recommended in South Canterbury[15], with the seed either being broadcast or shallow drilled (seed on, or just under, soil surface).

2.5.2 "Sheep's Burnet"

A perennial herb. Reputed to be hardy, tolerating dry, cool, low fertility environments. Slow to establish. *Sowing rate approximately 10 to 15 kg/ha* (plus clover), or 5 to 10 kg/ha in a pasture mix.

2.6 PASTURE TYPES FOR SOME SPECIFIC ENVIRONMENTS

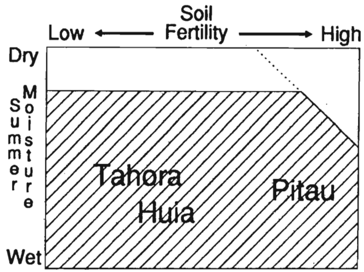
Note: Information is provided for only a few specific situations. Readers should consult sections 2.1 to 2.5 for further information on pasture varieties. The most appropriate species for any pasture is mainly determined by the four environmental factors of; temperature, soil moisture, soil fertility and pasture management[19].

2.6.1 Pastures for North Island Steep Hill Country

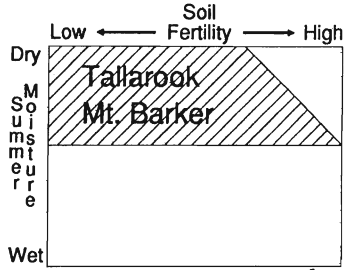
(Source: Chapman and MacFarlane, 1985. See reference[14] at end of Section 2)

The six diagrams on the following page show the suitability of different legumes and grasses for North Island Steep Hill country, taking into account variable soil fertility and summer moisture. The top right hand corner of each diagram (the area within the triangular shape) represents an environment probably unobtainable in hill country (high fertility, regularly summer dry).

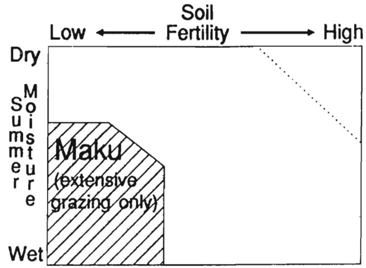
The bottom right hand diagram gives an overall picture of the types of pasture varieties generally recommended for oversowing hill country. This particularly applies to legumes, where a range of suitable annual and perennial varieties exists.



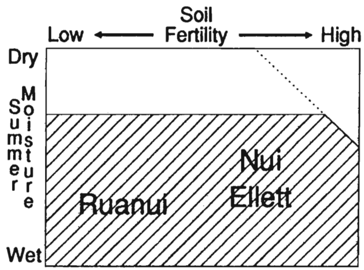
White Clover



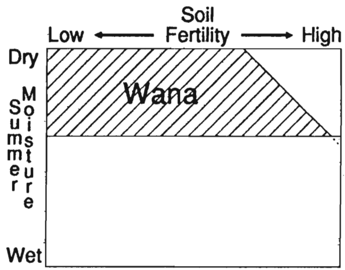
Subterranean Clover



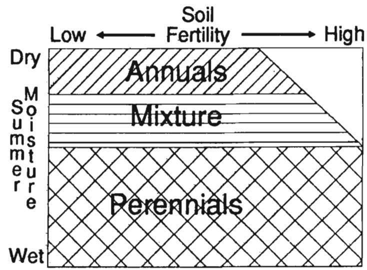
Lotus



Perennial Ryegrass



Cocksfoot



2.6.2 Pastures for Summer Dry/East Coast/Cultivatable Land.

(Source: Hume and Fraser, 1985. See reference[18] at end of Section 2)

Grass and legume species/cultivars available to farmers for the summer dry east coast of New Zealand, other than the traditionally used perennial ryegrass/white clover, fall into 3 categories:

1. Drought tolerant species/cultivars which will maintain production later into summer and respond quickly after drought, e.g. cocksfoot, tall fescue, lucerne, prairie grass.

2. Species/cultivars which will maximise production in winter and spring, e.g. prairie grass, phalaris, subterranean clover.

3. Species/cultivars compatible with summer crop programmes, e.g. annual ryegrasses.

Sowing requirements are detailed in Table 1, below.

Table 1: Sowing Requirements for Establishing New Cultivars in Dryland Pastures.

Species/cultivar (See Sections 2.1 to 2.5)	Time	Sowing Rate (kg/ha) Alone	In Pasture Mixture	Depth (cm)
Annual Ryegrass:				
-Tama	early autumn	30 kg	NR (Not Re-commended)	1-1.5 cm
Biennial Ryegrasses:				
-Paroa	early autumn	20-30	NR	1-1.5
-Moata	early autumn	30	NR	1-1.5
Hybrid Ryegrasses:				
-Manawa, Ariki	autumn	NR	5-10	1-1.5
Perennial Ryegrasses:				
-Ruanui,Nui,Ellet	autumn	15-20		1-1.5
Cocksfoot:				
-Wana	autumn	10-12	5-6	1-1.5
Prairie Grass:	early autumn	40 broadcast		2
-Matua	(spring)	(30 drilled)		
Tall fescue:				
-Roa, S170	autumn	25-30	NR	1-1.5
Phalaris	autumn	6	3	1-1.5
White clover	autumn	NR	3	0.5-1.5
Subterranean clover	autumn	NR	1-2	0.5-1.5
Red clover:				
-Pawera	autumn	NR	6	0.5-1.5
-Turoa, Hamua	autumn	NR	3	0.5-1.5
Lucerne	spring	5-6	NR	0.5-1.5

NR = Not recommended

2.6.3 Pasture Species for South Island Hill and High Country - Environmental Suitability

(Source: Scott *et al*, 1985. See reference[19] at end of Section 2).

The information given in Table 3 (page B-15) shows the relative tolerance and response of species to temperature and other factors. Table 2 (below) provides the key to Table 3. The South Island hill and high country region includes the particular features of lower temperatures and soil moistures, and the option of low soil fertility. Species and cultivars must be selected according to both their environmental suitability and their likely use, for example whether they will be grazed intensively or laxly. Readers should also refer to sections 2.1 to 2.5 for further details on specific pasture varieties.

Table 2: Key to Table 3 (page B-15)

Temperature
1. Cool temperature, high altitudes, south aspects
2. Moderate temperature and altitudes
3. Warm temperatures, low altitudes, sunny faces

Moisture

(a) Tolerance to moisture stress (drought)
1. Low
2. Moderate
3. High

(b) Suitability for sites with prolonged moisture stress
1. Low
2. Moderate
3. High

(c) Suitability for intensive irrigated pastures
1. Low
2. Moderate
3. High

(d) Value in livestock feeding systems
1. Low
2. Moderate
3. High

Soil Fertility

(a) Suitability for low fertility
1. Low
2. Moderate
3. High

(b) Sites where species is of greatest value
1. Low
2. Moderate
3. High

(c) Suitability for wet, acid and infertile soils
1. Low
2. Moderate
3. High

Grazing
1. Tolerates close or set-stocking
2. Intermediate
3. Requires lax or long regrowth periods as in hay production

Acceptability to Stock
1. Low
2. Moderate
3. High

Seed Rate in kg/ha (*Coated* and inoculated in case of legumes)

Table 3: Pastures for South Island Hill and High Country - Environmental Suitability.
(Note: Refer to Key on page B-14)

Species	Temp.	Moisture a	Moisture b	Moisture c	Moisture d	Fertility a	Fertility b	Fertility c	Grazing	Accept-ability	Seed rate
a)LEGUMES											
White clover	2-3	1-2	1-2	3	2-3	1	2-3	2	1	3	2-4
Red clover	1-2	1-2	1-2	3	2-3	1	2-3	1-2	3	3	2-4
Lucerne	2-3	3	3	3	1	1	3	1	3	3	4-10
Lotus	1-2	1	1	1	2-3	2	1-2	3	2	2	5-10
Birdsfoot trefoil	2-3	2-3	3	2	1	2	1-2	2	3	2	5-10
Suckling Clover	1	1	1	1	2-3	3	1	3	1	2	0.5-1
Subterranean clover	3	2-3	3	1	1-2	1	3		2	3	5-10
Greenfeed lupin	2	2	2	1	2	1	3	2	3	3	5-10
b)GRASSES											
Cocksfoot	1	2-3	2-3	2	1-2	2	1-2	2	2	3	5-15
Tall fescue	1	2	2	3	2-3	1-2	2-3	1	2	3	5-15
Perennial ryegrass	2-3	1-2	1-2	3	2-3	1-2	2-3	1	1	3	10-15
Hybrid ryegrass	2-3	1-2	1-2	3	2-3	1-2	2-3	1	2	3	10-15
Timothy	2	1	1	3	3	1-2	3	2	3	3	2-5
Browntop	1-2	2	2-3	1	1-2	2-3	1	3	1	2	0.25-2
Yorkshire fog	2	1-2	2	1	2	2	1	3	2	3	2-5
Phalaris	2-3	2	1-2	1-2	2-3	3	1	2	3	1-3	3
Crested dogstail	3	2	1	2	2	1-2	2	1	1	2	5
Annual ryegrass	2	2	1	3	2-3	1	3	1	2	3	15-25
Prairie grass	3	2	2		1-2	1	3	1	3	3	20-30
Kentucky bluegrass	2	2-3	3	1	2	2-3	1	1	1	1	0
Tall oat grass	2	3	3	1	1-2	3	1	1	3	2	1-3
Pubescent wheatgrass	3	3	3	1	2	3	1	1	2	2	1-3
c)HERBS											
Sheeps burnet	2	2-3	3	na	1	2	1	1	2	2	10-15
Chicory	3	2	2	na	2	1	3	1	3	3	2-5
d)SHRUBS											
Tree lupin	3	2	1	1?	2	2	1	2	2	1	5-15
Tagasaste/Tree lucerne	3	2	1	2?	1-2	1-2	2	1	3	2	2-5
Tree medick	3	3	1	1?	1	2	1	1	3	2	5
Saltbush	3	3	1	1	1	2	1	1	3	2	10
Mountain mahogany	3	3	1	1	1	2	1	1	2	1	10
Bluebush	3	3	1	1	1	2	1	1	3	2	10

2.7 WEED, PEST AND DISEASE CONTROL OF PASTURES AND LUCERNE

2.7.1 Use of Chemicals for Weed, Pest and Disease Control - General

The chemical control of weeds, pests, and diseases of plants, is dealt with in Sections 2.7.3 to 2.7.9 and Sections 3.2.4 to 3.2.10. They are intended as a guide only and for detailed information on products, active ingredients, application and dilution rates and for suitability of various chemicals for individual situations, farmers should consult their local Agricultural Chemical company representative, farm consultant, or refer to publications such as the 1990 "N.Z. Agrichemical and Plant Protection Manual", (obtainable from WHAM, P.O.Box 12-342, Wellington, or; The Bookshop, Lincoln University).
Trade names for chemicals are used only to acquaint the reader with some of the available chemicals and their matching common name. No preferential endorsement by the University is implied, nor is criticism implied of any chemical which does not appear in this Manual. Note that rates of product per hectare may depend on weed size and age or level or stage of pest or disease present, growth conditions, soil conditions and on the formulation of proprietary chemicals used. The label recommendation of the chosen product should always be followed. If in doubt, seek advice (refer above).

Remember to:
Read the instructions on the chemical container and follow carefully.
Obey any restrictions on use or withholding periods recommended.
Wear protective clothing and take any other suitable precautions against contact with chemicals.
Wash affected skin with water as soon as possible.
Prevent poisoning, especially of children, by storing chemicals in a locked shed and preventing access to the material in the field when applying.
Be aware of the first aid measures to take if someone is accidentally poisoned.

2.7.2 Toxicity Levels of Chemicals

The Toxic Substances Act 1979 specifies the classication of pesticides. LD_{50} values (measured in mg pesticide per kg bodyweight of the test animal) refer to the amount of chemical estimated (on the basis of tests) to kill 50% of a group of animals.

Table of Oral and Dermal LD_{50} values for Solid and Liquid Chemicals

	Solids		Liquids	
Class	Oral	Dermal	Oral	Dermal
1.	up to 5	up to 10	up to 20	up to 40
2.	5 to 50	10 to 100	20 - 200	40 to 400
3.	50 to 500	100 - 1000	200 - 2000	400 to 4000
4.	500 or more	1000 or more	2000 or more	4000 or more

Class 1 = Deadly Poison, Class 2 = Dangerous Poison, Class 3 = Poison, Class 4 = Harmful Substance.

Note: There are a number of registered pesticides that are not included in this Act but are included under the Pesticides Act and Regulations.

2.7.3 Weed Control in Pastures

Weed	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Barley Grass	carbetamide	Carbetamex 70	4 kg/ha
	simazine	Simazine 500FL, Gesatop 500FW/Simatox	160ml (90g)/ha (or + Gramoxone for spot spray)
	propyzamide	Kerb Flo	1 litre/ha
Bracken (see also 2.7.4)	asulam	Asulox	11 litres/ha
Buttercups	MCPA	MCPA	3 litres/ha
Californian Thistle	dicamba	Banvel/Dicamba	250 ml/ha (use in conjunction with 500 ml MCPA/ha)
Docks	asulam	Asulox	3 litres/ha
		Selecta 4-CPA	7 litres/ha
Gorse	- see scrub control (Section 2.7.4)		
Most Broadleaved Weeds and Thistles	bentazone	Basagran	3 litres/ha, for newly established pasture
	2,4-D amine	2,4-D Amine	3 litres/ha
	2,4-D B	2,4-D B (IWD)	6 litres/ha (seedling stage)
	2,4-D Butyl Ester	IWD Hi-Ester	750 ml/ha
	2,4-D Sodium Salt	2,4-D Sodium salt (Nu Farm)	1.3 kg/ha as a dust or spot spray
	MCPA	MCPA	3 litres/ha
	MCPB	MCPB	6 litres/ha (seedling stage)
Nettles	MCPA	MCPA	4 litres/ha
Nodding and Winged Thistles	clopyralid	Lontrel Pasture	1 litre/ha - very early growth stage 2 litres/ha - where crowns are >35-40mm in diameter.
Ragwort	2,4-D Ester	various	2 litres/ha (seedling ragwort)
	dichlorbenil	Prefix-D	apply pellets (1/4 tsp) directly to plant
	dicamba	Dicamba	300 ml + 500 ml 2,4-D Ester/100 litres, spot spray
Storksbill	bentazone	Basagran	4 litres/ha, use with penetrating agent.
	4-CPA (iso-octyl ester)	Selecta 4-CPA	4 - 5 litres/ha

2.7.4 Specific Scrub and Woody Weeds

Weed	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Barberry	metasulfuron	Escort	Handgun 35 g/100 litres, Knapsack 50 g/100 litres
	glyphosate	Roundup	Handgun 1 litre/1600 l, Knapsack 150 ml/15 litres
	sodium chlorate	Sodakem	500 g/bush (15 cm trunk)
	picloram	Tordon 2G	55 g per sq. metre (pellets)
	picloram, triclopyr	Tordon Brushkiller	600 ml/100 litres water
	triclopyr	Grazon	1:20 water/diesel and paint stumps post-cutting
Blackberry	amitrole	Amitrole	1.5 l/100 litres of water
	ammonium sulphamate	Anmate XL	8 litres/100 litres of water
	metasulfuron	Escort	Handgun 20 to 35g/100 l of water; Knapsack 50g/100 l of water
	triclopyr	Grazon	300 ml/100 litres water
	picloram	Tordon 2G	as for barberry
	picloram, triclopyr	Tordon Brushkiller	500 ml/100 litres of water
	hexazinone	Velpar 90	as for gorse (next page)
	hexazinone	Velpar L	as for gorse
	hexazinone	Velpar 20G	as for gorse
Boxthorn	ammonium sulphamate	Ammate XL	as for blackberry
	glyphosate	Roundup	1.25 litres/100 litres of water
	picloram	Tordon 2G	as for barberry
Bracken (see also 2.7.3)	ammonium sulphamate	Ammate XL	as for blackberry
	metasulphuron	Buster	10 litres/hectare
	glufosinate-ammonium	Escort	as for barberry
	glyphosate	Roundup	handgun 1 litre/100 litres) + penetrant knapsack 150 ml/15 litres)

(continued on Next Page)

Weed	Chemical (a.i.)	Examples of Product	Application Rate of Product (<u>Not</u> a.i.) *(Manufacturer's <u>Minimum</u> Recommendation)*
Bracken (cont.)	iso-octyl ester	Selecta-4-CPA	17 litres/ha (just prior to fronds being fully expanded)
	hexazinone	Velpar 90	as for gorse
	hexazinone	Velpar L	as for gorse
	hexazinone	Velpar 20G	as for gorse
Broom	amitrole	Amitrole	2 litres/100 litres of water
	ammonium sulphamate	Ammate XL	as for blackberry
	glufosinate-ammonium	Buster	7.5 litres/hectare
	metasulfuron	Escort	as for barberry
	triclopyr	Grazon	200 ml/100 litres of water during active growth 300 ml/100 litres of water rest of the year
	glyphosate	Roundup	as for bracken
	picloram	Tordon 2G	30 g/m^2
	picloram, triclopyr	Tordon Brushkiller	250 ml/100 litres of water
	hexazinone	Velpar 90	as for gorse
	hexazinone	Velpar L	as for gorse
	hexazinone	Velpar 20G	as for gorse
	clopyralid amine salt	Versatill	as for gorse
Gorse	amitrole	Amitrole	as for broom
	ammonium sulphamate	Ammate XL	as for blackberry
	glufosinate-ammonium	Buster	as for broom
	metasulfuron	Escort	handgun 20 g/100 l of water; knapsack 50 g/100 l
	triclopyr	Grazon	as for broom
	hexazinone	Velpar 90	6 - 8 kg/ha, 500g/100 l of water for spot spraying
	hexazinone	Velpar L	2 litres/100 litres of water for spot spraying
	hexazinone	Velpar 20G	30 - 40 kg/ha
	clopyralid amine salt	Versatill	500 ml/100 litres of water

Weed	Chemical (a.i.)	Examples of Product	Application Rate of Product (<u>Not</u> a.i.) *(Manufacturer's <u>Minimum</u> Recommendation)*
Hawthorn	metasulfuron	Escort	as for barberry
	triclopyr	Grazon	as for barberry
	picloram, triclopyr	Tordon Brushkiller	1:20 in water, paint on plant, post-cutting
	clopyralid amine salt	Versatill	as for gorse
Lupin	triclopyr	Grazon	150 ml/100 litres of water
	picloram	Tordon 2G	as for broom
	picloram, triclopyr	Tordon Brushkiller	100 ml/100 litres of water
	picloram, 2,4-D	Tordon 50D	500 ml/100 litres of water
	clopyralid amine salt	Versatill	200 ml/100 litres of water
Manuka/Teatree	ammonium sulphamate	Ammate XL	125 ml/litre of water
	metasulfuron	Escort	as for barberry
	hexazinone	Velpar 90	as for gorse
	hexazinone	Velpar L	as for gorse
	hexazinone	Velpar 20G	as for gorse
Matagouri	metasulfuron	Escort	handgun 25 g/100 litres of water; knapsack 50 g/100 l of water
	picloram	Tordon 2G	as for blackberry
	picloram, triclopyr	Tordon Brushkiller	as for blackberry
Nasella Tussock	dalapon	Dalapon/Basfapon	22-44 kg in 200-400 litres water/ha (regrowth after burning at lower rates); 2-6 kg seedling
Old Man's Beard	glyphosate	Roundup	handgun 1 - 2 ml/100 litres; knapsack 300 ml/15 litres of water
	clopyralid amine salt	Versatill	12-15 litres/ha or 500 ml/100 litres
Pampas (Toi toi)	haloxyfop	Gallant	handgun 1 litre/100 litres water knapsack 300ml/10 litres water
	glyphosate	Roundup	as for bracken
	hexazinone	Velpar 90	25 g/litre spot applications
	hexazinone	Velpar L	4 ml direct to plant
	hexazinone	Velpar 20G	10 - 20 kg/ha

Weed	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Raupo	amitrole	Amitrole	as for broom
	dalapon	Dalapon	as for nasella tussock
Rushes	amitrole	Amitrole	as for broom
	glufosinate-ammonium	Buster	as for bracken
	2,4-D	Hi-ester,	handgun 125 ml gramoxone +
	paraquat	Gramoxone	500 ml 2,4-D in 100 litres of water/ha
	glyphosate	Roundup	as for bracken without the penetrant
Sedges	glufosinate-ammonium	Buster	as for bracken
	dalapon	Dalapon/Basfapon	11-15 kg in 300-400 litres of water/ha
	2,4-D	Hi-ester,	as for rushes
	paraquat	Gramoxone	
	glyphosate	Roundup	as for bracken without the penetrant
Sweet Briar	metasulfuron	Escort	as for barberry
	triclopyr	Grazon	500 ml/100 litres of water
	picloram	Tordon 2G	as for gorse
	picloram, triclopyr	Tordon Brushkiller	as for gorse
	hexazinone	Velpar 90	as for gorse
	hexazinone	Velpar L	as for gorse
	hexazinone	Velpar 20G	as for gorse
Tauhina	picloram	Tordon 2G	as for barberry
Tutu	metasulfuron	Escort	as for barberry
	picloram	Tordon 2G	as for barberry
Wild Ginger	metasulfuron	Escort	as for barberry
Willows	ammonium sulphamate	Ammate XL	as for manuka
	triclopyr	Grazon	as for barberry
	2,4-D	Hi-ester 2,4-D	6 litres/ha (200-400 litres water)

2.7.5 Control of Insect Pests of Pasture

Insect	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Argentine Stem Weevil	chlorpyrifos	Chlorpyrifos 48EC	1.25 litres/ha
	phorate	Phorate, Thimet 20 G	5 kg/ha down drill
	oxamyl	Vydate L	2 litres/ha
Black Field Cricket	maldison	Maldison, Malathion	Use as bait, wheat soaked in mixture of 300 ml chemical per 11 kg wheat
Grass Grub	terbufos	Counter 20G	3 kg/ha down drill
	diazinon	Diazinon 80 EC	3 litres/ha
	diazinon	Gesapon 20G	11 kg/ha worked in or drilled with seed @ 5.5 kg/ha
	phorate	Phorate, Thimet 20 G	5 kg/ha down drill
Lucerne Flea	chlorpyrifos	Chlorpyrifos 48EC	250 ml/ha
Porina	chlorpyrifos	Chlorpyrifos	1.5 litres/ha
	diazinon	Diazinon 80 EC	1 litre/ha
	diazinon	Gesapon 20G	11 kg/ha worked in or drilled with seed @ 5.5 kg/ha
	fenitrothion	Caterkill 60, Verthion EC	1 litre/ha
Army Caterpillar	methomyl	Lannate L	1.5 litres/ha

2.7.6 Disease Control in Pasture

Head Smut Prairie grass
Treat all seed with thiram, benomyl (Benlate). Benomyl at 5 g a.i./kg seed is preferred, though recent research shows that Baytan IM is effective.

Leaf Rust of Ryegrass
Can cause yield losses and/or reduce the palatability of grass especially in the autumn. Use cultivars which have improved rust tolerance, such as "Supernui" and "Greenstone", (see Section 2.2.1).

References:

Close, R.C. 1990: "Pasture Plant Diseases" in "Pastures their Ecology and Management". Edited by R.H.M. Langer, Oxford University Press, 499 pp.

2.7.7 Weed Control in Lucerne

Weed	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Broad Leaved Weeds and Grasses	atrazine	Atradex, Atrazine, Gesaprim	1.5 litres/ha + 2 Litres/ha Gramoxone
	bentazone	Basagran	4 litres/ha (or lowered if combined with 2,4-DB).
	cyanazine	Bladex	2 litres (1-1.5 kg)/ha, use with gramoxone
	chlorpropham	Chloro I.P.C.	8 litres/ha
	EPTC (thiocarbamate)	Eradicane Super	6 litres/ha
	terbuthylazine	Gardoprim 500FW	1.5 litres/ha (with gramoxone)
	metribuzin	Sencor 70 DF	1 kg/ha (dormancy)
	simazine	Flowable Simazine, Gesatop	1.5 litres (800 g) + 2-3 litres gramoxone per ha
	trifluralin	Treflan	1.5-2 litres/ha depending on soil texture (pre-emergence)
	haloxyfop	Gallant	1.2 litres/ha
	chlorimuron ethyl	Classic	120 g/ha established stands only
	hexazinone	Velpar L	4 litres/ha
Grasses and Twitch (Couch)	carbetamide	Carbetamex 70	4 kg/ha
	haloxyfop	Gallant	1.3 litres/ha established (dormancy)
	propyzamide	Kerb Flo	2 litres/ha seedling stage
Docks	asulam	Asulox	3 litres/ha

2.7.8 Insect Control in Lucerne

Insect	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Aphids	chlorpyrifos	Chlorpyrifos 48EC	300 ml/ha
		Lorsban 40 EC	300 ml/ha
	deltamethrin	Decis	250 ml/ha
	disulfoton	Disyston 10G	10 kg/ha down drill, or broadcast and incorporate pre-drill
	thiometon	Ekatin	400 ml/ha
	demeton-S-methyl	Metasystox	300 ml/ha
	phorate	Phorate, Thimet 20 G	5 kg/ha down drill
	pirimicarb	Pirimor 50	200 g/ha
	dimethoate	Rogor E	300 ml/ha
		Rogor 20 W	600 g/ha
	fenvalerate	Sumicidin	125 g/ha
Lucerne Flea	chlorpyrifos	Chlorpyrifos 48EC	250 ml/ha
		Lorsban 40 EC	250 ml/ha
Sitona Weevil	chlorpyrifos	Chlorpyrifos 48EC	750 ml/ha
		Lorsban 40 EC	750 ml/ha
	deltamethrin	Decis	250 ml/ha
	fenitrothion	Caterkill 60, Verthion EC	1 litre/ha
		Lorsban 40 EC	250 ml/ha
	maldison	Maldison, Malathion	300 ml/ha

2.7.9 <u>Control of Lucerne Diseases</u>

(Contributed by Dr R.C.Close - Biochemistry and Microbiology Department, Lincoln University).

There are a number of diseases that can affect these crops and seriously reduce yield.

Soil-borne diseases

- Bacterial wilt - use resistant cultivars (see page B-10).
- Phytophthora root rot - use resistant cultivars (see page B-10).
- Verticillium wilt - some cultivars are partially resistant.

Fungicide Treatment of Seed

Seed, especially pelleted seed, is generally treated with fungicides that do not interfere with, or inhibit, the nodulation process. Treatment of lucerne seed is now recommended, using products that contain metalaxyl.

Air-borne diseases

- Common leaf spot
- Stemphylium leaf spot
- Pepper spot
- Spring black stem and leaf spot and other fungal leaf spots - use resistant cultivars (see page B-10). With susceptible cultivars, spray with benomyl especially crops being used for seed production.

References in: "Lucerne for the 80's" Agronomy Society of New Zealand Special publication No. 1.

2.8 <u>FORAGE SHRUBS/BROWSE SPECIES:</u>

(Note: See also Section 2.6.3, Table 3, page B-15).

Tagasaste (tree lucerne), Dorycnium (Canary clover), Honey locust, Tree medic.

2.9 ESTIMATING PASTURE DRY MATTER (D.M.)

2.9.1 Summary of Methods Used to Estimate Dry Matter:

Note: Dry Matter (D.M.) = the weight of pasture less the water content.

Methods Used:

- Eye assessment - *see Section 2.9.2, below.*
- Using commercially available instruments: *(see Section 2.9.3, page B-29)*
    (1) "Pasture Probe"
    (2) "Rising Plate Meter"
- Cutting and weighing a sample of pasture, and drying a small quantity to determine the dry matter content/percentage - *see Section 2.9.4, page B-29.*
- Cutting and weighing pasture, and estimating D.M. content/percentage without drying - *see Section 2.9.5, page B-31.*

2.9.2 Using Eye Assessment to Estimate D.M.

This involves the assessment of the total pasture dry matter in a paddock, measured right to ground level. Most pastures yield between 500 and 3500 kilograms of dry matter per hectare, depending on length, density, stage of growth, time of year and species present.

The easiest way to learn eye assessment is to "compare notes" with an experienced consultant or farmer, preferably one who "calibrates" his or her assessment by cutting, weighing and drying pasture samples regularly (see 2.9.4, page B-29).

With experience, and occasional "calibration", eye assessment can be reasonably accurate: to within 100 to 300 kg D.M./ha of "actual".

See over page for guidelines for eye assessment:

For ryegrass/white clover based pastures, the following figures may be used as an approximate guide only in autumn, winter and spring (accurate assessment is far more difficult in late spring and summer):

Average Height of Pasture:	Type of Pasture: Sheep & Cattle Pasture (relatively dense)	Dairy Pasture (erect, less dense)
"2 Centimetre Scale":		
The *first* 2cm above ground* -	800-1000 kgD.M./ha	500-700 kg D.M./ha
Every 2cm in height thereafter- (Up to about 12cm, maximum.)	about 400 kg D.M./ha	about 300 kg D.M./ha
"2.5 cm (1 inch) Scale":		
The *first* 2.5cm (1") above ground level* -	1000-1200 kg D.M./ha	700-800 kg D.M./ha
Every 2.5cm in height thereafter - (Up to about 12 cm, maximum)	about 500 kg D.M./ha	350-400 kg D.M./ha

* *Note: For pastures less than 2.0 to 2.5 cm in height, it is difficult to be precise. Sheep pasture grazed very short, and showing a lot of bare ground, is about 400 kg D.M./ha. Dairy pasture grazed very short by cows is about 600 kg D.M./ha. Winter pasture of only 1 cm in length is about 600 kg D.M./ha whereas spring or autumn pasture is about 800 kg D.M./ha (minimum).*

Useful tips for Eye Assessment:

(a) The base of the pasture has a high proportion of stems and dead matter, which have a higher dry matter content (than green leaf material). This factor is accounted for in the table above.
(b) Long pastures (greater than 12 to 15 cm in length) are easily over- estimated. The quantity of dry matter per centimetre becomes proportionately less for every increase in length/height.
(c) Grasses going to seed, rapidly increase in dry matter content, making eye assessment difficult in ryegrass paddocks through late spring and summer. Other grasses to watch out for (at seeding) are the poas, barley grass, browntop, paspalum and the danthonias.
(d) Clover dominant pastures have a lower dry matter content.
(e) The table (above) does not apply to 'other' pasture species: lucerne, brown-top, prairie grass, paspalum and cocksfoot.
(f) Pasture density and the amount of bare ground should be taken into account.
(g) The quantity of dead matter in the pasture will have an impact on feed quality and acceptance by stock, and may need to be discounted.

Paddock Assessment:

(a) Walk through the paddock so that all the pasture can be seen. At regular intervals, stop and make an assessment of the pasture in the immediate vicinity. At the finish, work out an average figure (in kg D.M./ha) for the paddock.

(b) Some sources recommend mentally dividing the paddock into 4 to 5 equal sections, assessing the pasture in each section, then calculating the average.

(c) Hill country paddocks are more difficult to assess, because of the variation in pasture length, density and composition etc. There might be four or more distinctly different sections within a paddock which need assessment. Finally, when working out the average for the paddock, the area of each distinct section must be taken into account, along with the D.M. estimate for that section.

2.9.3 Using "Pasture Probe" or "Rising Plate Meter" to Estimate D.M.

Both instruments are readily available in New Zealand, and can be of great assistance in assessing pasture dry matter. As with eye assessment, however, pasture cuts etc. (see 2.9.4, below) should be made to "calibrate" the probe or meter.

2.9.4 Using "Cut and Dry" Technique to Measure D.M.

(Note: see also 2.9.6, page B-31)

This method should give the most accurate assessment of pasture dry matter, and is used to calibrate and check the accuracy of eye assessment, probes and meters.

A representative section of pasture is selected, and a measured area (the larger the better) of this is clipped to ground level*. Commonly the area is either 0.1 or 0.25 square metres, represented by squares with sides of either 32 cm or 50 cm, or by circles with diameters of either 36 or 56 cm.

Soil should be removed (by washing if necessary) from the sample, which is then weighed. After thorough mixing, a 200 gram (accurately weighed) sub-sample** is taken and dried in an oven at 100°C for 24 hours (or until the sample stops losing weight/moisture), then weighed again.

* *See discussion on pasture clipping technique, page B-31.*

** *200 gm sub-sample: Or alternatively, all of the sample can be dried.*

See over page for the calculations required

Calculation Required:

a) When Clipping An Area of 0.25 Square Metres:

Example: the sample weighs say, 300 grams. A sub-sample (see page B-29) weighing 200 grams*** is dried for 24 hours, by which time the weight has reduced to, say, 30 grams.

The calculations required to obtain the dry matter figure in terms of kilograms of dry matter (D.M.) per hectare are as follows:

Green Weight (300 grams), multiplied by Dry Weight of Sub-Sample (30 grams), multiplied by 40 (to convert to kg/ha) divided by Green Weight of Sub-Sample (200 grams) equals:

$$300 \times 30 \times 40 \div 200 = 1800 \text{ kg Dry Matter per hectare}$$

*** *200 gm sub-sample: Or alternatively, all 300 gm can be dried, and the final weight of dried grass is multiplied by 40 to give kg D.M. per ha.*

b) ***When Clipping An Area of 0.1 Square Metres:***

Example: the fresh sample weighs say, 120 grams. The entire quantity (see *Note 1.*, below) should be dried and weighed again (say: 20 grams). The calculations required are:

Dry Weight (20 grams) multiplied by 100 (to convert to kg/ha), equals:

$$20 \times 100 = 2000 \text{ kg Dry Matter per hectare}$$

Note 1: If the total green pasture cut weighs less than 200 grams, all of it should be placed in the oven. If it weighs more than this, a sub-sample of 200 grams can be selected and dried - see above.

Use of Microwave to dry pasture:

(Note: The following recommendation is tentative only.)

a) place a weighed sub-sample (see above) in a suitable container in the microwave oven.
b) also place a small plastic container (or glass) filled with water in the oven.
c) start microwave for an initial 5 minutes.
d) weigh sample immediately.
e) replace in oven for an additional two minutes. Reweigh.

Use the second weight figure if it is less than in (d) above, unless it is apparent that a third drying will be required.

2.9.5 Estimating D.M. from Green Pasture Cuts *(Without Drying)*

(Note: see also 2.9.6, below).

This is a more "rough and ready" method. The sample should be cut and weighed when green, as in 2.9.4, page B-29. Next, reference should be made to the Table in *Section 1.11.1*, and a dry matter percentage figure selected for the type of pasture being considered; for example, "spring, short leafy ryegrass/white clover pasture" is shown to have a dry matter percentage of 15%.

For a 0.25 square metre area, the calculations are:
Green Weight (300 gms), multiplied by D.M. percentage (15%), multiplied by 0.4 (to convert to kg/ha), equals:

300 x 15 x 0.4 = 1800 kilograms of dry matter per hectare.

For a 0.1 square metre area, the calculations are:
Green Weight (120 gms), multiplied by D.M. percentage (15%), equals:

120 x 15 = 1800 kilograms of dry matter per hectare.

2.9.6 Pasture Clipping Technique - Discussion

Hand clippers, or even battery-driven clippers, cannot cut as close to the ground as can motor driven clippers which are commonly used by researchers (e.g. M.A.F. Ruakura). One feed assessment expert (Milligan, 1981) estimated that motor driven clippers may harvest as much as 200 to 300 kg D.M./ha more (after the soil has been washed out) than battery driven clippers. This factor should be borne in mind when adapting research recommendations to the 'on-farm' situation, particularly when stock are being forced to graze to very low levels (low residual dry matter).

2.9.7 Estimating Hay and Silage D.M.

Note 1: Dry Matter is the weight of feed less the water content.
Note 2: Wastage from harvest to feeding out can be significant - up to 50% for silage).

Hay:
(about 80 to 85% Dry Matter):

	Kg of Dry Matter Per Bale:	*Actual Weight Per Bale:*
Conventional, "Small" Bales:	15-20 kg	*19-24 kg*
"Round" Bales: (equivalent to 11 to 14 small bales)	200-240 kg	*240-290 kg*

Haylage:
About 40 to 60% dry matter.

Grass (Pasture) Silage:

(1.) Direct cut, wet silage - usually 15 to 18% dry matter
Wilted silage - usually 25 to 35% dry matter

(2.) Simple guide to estimate dry matter content of harvested pasture:
When the pasture is twisted by hand:
- if the pasture is wet, and juices are easily expressed: 15 to 17% D.M.
- if juice expressed with some difficulty: 18 to 22% D.M.
- if very difficult to express juices, but hands are moist: 23 to 27%D.M.
- if impossible to express juice: over 27% D.M.

(See also Section 2.9.4 - Drying herbage to measure D.M.content).

(3.) Paddock Yields of Silage Crops:
(approximate guide).

a) Paddock closed for 6 Weeks (spring):
- Total Dry Matter harvested : 2000 to 2200 kg per hectare.
  [hay equivalent: 110 to 120 bales/ha (40 to 50 bales/acre)].
- Actual green weight of pasture mown: 11 to 12 tonnes/ha
- Actual weight of pasture, after wilting: 7 to 8 tonnes/ha

b) Paddock closed for 8 weeks (spring/early summer):
- Total Dry Matter harvested: 3000 kg per hectare
  [hay equivalent: 160 to 170 bales/ha (65 to 70 bales/acre)]
- Actual green weight of pasture mown: 13 to 14 tonnes/ha
- Actual weight of pasture, after wilting: 10 tonnes/ha

(4.) Silage Stack Density (Stack Well Settled):

	Kg of Dry Matter per cubic metre*:	*Actual Weight (including moisture) per cubic metre:*
Direct cut	90 to 140 kg	*700 to 900 kg*
Wilted	150 to 200 kg	*550 to 800 kg*

(* cubic metre = 35.3 cubic feet)

Pasture Hay and Silage Quantity Comparisons:
1 tonne (actual weight) of direct cut silage contains about the same quantity of Dry Matter as 8 to 10 (small) bales of hay.
1 tonne (actual weight) of wilted silage contains about the same quantity of dry matter as 15 to 17 (small) bales of hay.

Maize Silage:

Dry Matter Content	Stack Density: (kg D.M. per cubic metre)	Stack Density: (Actual weight per $metre^3$)	Yield Harvested per hectare (tonnes of D.M.)
30 - 35 %	150 - 200 kg	500 - 600 kg	10 - 20

2.10 PASTURE GROWTH RATES FOR FEED BUDGETING

2.10.1 Estimating Farm Pasture Production

Feed budgeting or feed planning involves the use of estimates of likely pasture growth/production for the farm. Research information can provide the basis for these estimates. Information from various sources has been included in Sections 2.10.2 to 2.10.5 inclusive.

Consultants and researchers can help farmers to adapt this information to the 'on-farm' situation. Factors such as soil fertility, pasture species, slope and aspect need to be taken into account.

There are also computer programs available that can be used to predict pasture growth rates for the short term future, based on soil temperature and moisture readings on the farm.

However, records kept (by the farmer) of *actual* growth rates on the farm over a number of years are probably the best source of information for feed budgeting.

Checking Estimates of Annual Production:
Once an estimate has been arrived at, the figures can be roughly checked by calculating the stocking rate of the farm and estimating the amount of pasture the stock must be consuming over the space of a year; for example:

Example 1:
A medium hill country sheep and cattle farm is carrying, say, 10 stock units per hectare (see Section 1.12 for s.u. measures of livestock types). One stock unit (s.u.) eats about 550 kg* of pasture dry matter per year. Therefore the stock carried on one hectare must be consuming about 10 x 550 kg = 5,500 kg dry matter per year. However, over the space of a year probably about 25% of the pasture grown is "wasted", mainly due to decay in the base of the pasture. In other words, only about 75% of the pasture grown is consumed or utilised (extremely high utilisation is about 90%, extremely low utilisation is about 50 to 60%). Therefore the hectare must be growing approximately 7,300 kg of DM in total, each year - the calculation is as follows:

Dry matter consumed per hectare (5500 kg) divided by the utilisation figure (75) multiplied by 100:

5,500 + 75 × 100 = 7,333 kg of pasture dry matter is grown per hectare per year.

* *(Note: Scientific opinion differs as to the exact quantity of D.M. eaten).*

See over page for example 2.

Example 2:
A high producing dairy farm is carrying 3 Friesian cows (450 kg liveweight, 180 kg milkfat per head) per hectare. With each cow being "worth" 7.5 stock units (see Section 1.12), this works out to 22.5 stock units per hectare. Therefore the stock on one hectare must be consuming about 22.5 x 550 kg = 12,375 kg of dry matter per year. It is estimated that only about 15% of the pasture grown is "wasted" in the space of a year, that is, about 85% of the pasture grown is consumed or utilised.
Therefore the calculation is:
Dry matter consumed per hectare (12,375 kg) divided by the utilisation figure (85) multiplied by 100:

12,375 ÷ 85 x 100 = 14,560 kg of pasture dry matter is grown per hectare per year.

Another "check" for dairy farms is to multiply the milkfat production figure (kg per hectare) by 23* to determine the pasture consumed. Therefore the calculation is - cows per hectare (3) multiplied by milkfat produced per cow (180 kg) multiplied by 23:

3 x 180 x 23 = 12,420 kg of pasture dry matter consumed per hectare per year

(This figure would then be divided by 85 and multiplied by 100 to obtain total pasture D.M. grown).

* *(Note: Likely range is 20 to 24).*

2.10.2 Pasture Growth Rates for N.Z. Regions/Districts:

Refer to Tables 1 and 2, page B-36 and B-37, for data on average growth rates for a number of North and South Island regions and districts.
(For further information see N.Z. Journal of Experimental Agriculture: Vol 2 onwards - J.E. Radcliffe *et al.* Also refer to Note 1. below).

Note 1: While the growth data in Tables 1 and 2 should be a good guide, they do have limitations:

- *(i) They are specific to the research site, soil conditions and pasture composition.*
- *(ii) They were collected from areas usually continuously grazed by sheep.*
- *(iii) They were calculated by measuring the regrowth of pasture, two weeks after it had been trimmed.*

Table 1 - Pasture Growth Rates: North Island Sites
(kilograms of dry matter grown per hectare per day)

Site:	*Helensville*	*Dargaville*	*Rukuhia (Hamilton)*	*Manutuke (Gisborne)*	*Wairakei [Flat site]*	*Wairakei [Hill site]*	*Marton*	*Bulls*	*Masterton*	*Maraekakaho (Hastings)*
Soil type:	Red Hill Sand Complex	Kaipara Clay	Hamilton Clay Loam	Recent Alluvial Soils	Atiamuri Sand	Oruanui Hill Soil	Marton Silt Loam	Rangitikei Loamy Sand	Katatau Silt Loam	Takapau Light Silt Loam
	Example: 17(±11). Average figure is 17kg/day. Usual range is from 6 to 28 kg/day.*									
Month:										
Jun	**17(± 11)**	25(±12)	8(±4)	18(±13)	4(±3)	8(±3)	12(±6)	13(±12)	16(±5)	10(±5)
Jul	18(±12)	24(±9)	12(±7)	19(±8)	5(±3)	7(±3)	13(±6)	5(±5)	16(±4)	10(±6)
Aug	29(±14)	33(±11)	32(±11)	33(±12)	5(±3)	11(±5)	23(±9)	8(±4)	32(±8)	20(±8)
Sep	37(±15)	50(±16)	50(±15)	47(±14)	17(±12)	29(±9)	44(±12)	21(±7)	56(±14)	40(±15)
Oct	51(±17)	58(±15)	53(±18)	47(±16)	30(±14)	45(±20)	47(±16)	27(±8)	70(±19)	40(±20)
Nov	50(±20)	63(±20)	44(±21)	38(±17)	33(±13)	42(±12)	40(±20)	28(±16)	51(±10)	13(±22)
Dec	45(±24)	73(±25)	42(±24)	37(±20)	33(±20)	52(±18)	43(±23)	22(±12)	30(±24)	14(±21)
Jan	32(±21)	59(±20)	17(±18)	29(±18)	19(±20)	34(±22)	32(±25)	17(±19)	15(±18)	9(±14)
Feb	29(±23)	61(±23)	21(±23)	30(±17)	14(±15)	18(±16)	26(±14)	19(±10)	12(±18)	13(±11)
Mar	31(±14)	50(±18)	21(±19)	32(±22)	11(±20)	24(±21)	29(±14)	15(±13)	21(±24)	15(±13)
Apr	36(±15)	41(±21)	23(±13)	29(±14)	9(±7)	18(±8)	25(±11)	14(±11)	26(±18)	18(±14)
May	26(±16)	32(±13)	13(±7)	24(±13)	8(±7)	13(±8)	17(±7)	15(±14)	25(±7)	18(±11)
Total**:	12750	17150	10200	11750	5750	9000	10850	6250	10900	6750
Range*:	10400-15150	13550-20750	8000-12400	9050-14450	4300-7200	7600-10420	8900-12800	5500-7050	8500-13300	5550-7950

* Range: Daily (yearly) production falls within this range in most (two out of three) years.
** Total: Production per hectare *per year* (on average).

<u>Table 2 - Pasture Growth Rates: South Island Sites</u>
(kilograms of dry matter grown per hectare per day)

Site:	***Westport***	***Motueka***	***Winchmore (Ashburton) [Dryland***	***Winchmore [Irrigated]***	***Cromwell***	***Invermay (Dunedin)***	***Invermay [Hill Site]***	***Mona Bush (Invercargill)***	***Winton (Invercargill)***
Soil type:	Addison "Pakihi"	Rosedale Hill Soil	Lismore Stony Silt Loam *(see also Section 2.10.5)*	Lismore Stony Silt Loam	Molyneux Loamy Sand	Alluvial Soil	Warepa Series	Waikiwi Silt Loam	Otapiri Silt Loam
	<u>Example</u>: 11(±6). Average figure is 11kg/day. Usual range is from 5 to 17 kg/day.*								
Month:									
Jun	**11(±6)**	13(±5)	5(±3)	5(±3)	0(±0)	5(±2)	5(±4)	6(±2)	8(±6)
Jul	10(±6)	17(±6)	5(±2)	5(±3)	0(±0)	5(±2)	5(±4)	5(±3)	9(±4)
Aug	13(±7)	30(±8)	9(±3)	11(±4)	0(±0)	12(±5)	9(±5)	8(±3)	10(±6)
Sep	16(±5)	58(±21)	30(±8)	31(±10)	16(±18)	32(±12)	25(±10)	35(±15)	26(±14)
Oct	38(±14)	57(±20)	37(±11)	40(±6)	39(±25)	55(±16)	46(±16)	35(±17)	53(±14)
Nov	55(±15)	55(±23)	27(±15)	41(±14)	48(±23)	49(±19)	47(±18)	70(±32)	54(±19)
Dec	54(±13)	36(±29)	19(±12)	48(±14)	52(±26)	47(±18)	44(±20)	69(±25)	54(±24)
Jan	49(±17)	15(±24)	13(±14)	48(±8)	42(±16)	40(±17)	36(±18)	58(±13)	53(±20)
Feb	40(±7)	14(±22)	14(±12)	43(±10)	35(±11)	33(±13)	28(±16)	58(±20)	51(±29)
Mar	32(±5)	32(±31)	16(±10)	31(±10)	27(±11)	29(±12)	24(±14)	49(±14)	42(±17)
Apr	21(±9)	30(±25)	14(±9)	20(±9)	13(±7)	18(±9)	16(±9)	31(±13)	26(±12)
May	10(±6)	16(±7)	8(±4)	10(±5)	3(±3)	8(±8)	9(±5)	10(±5)	13(±9)
Total**	10900	11550	5850	10150	8300	10400	8900	14600	12000
Range*	10200-11650	9500-13600	4750-6700	9150-11200	6700-9900	8800-12000	6500-11100	11850-17350	9700-14300

* Range: Daily (yearly) production falls within this range in <u>most</u> (two out of three) years.
** Total: Production per hectare *per year* (on average).

2.10.3 Dairy Farm Pasture Growth Rates:
(Note: See also Section 2.10.2)

(1) Autumn/Winter/Spring Growth on New Zealand Dairy Farms:
(ryegrass/white clover[23] - daily growth rates - kg D.M./ha/day)

	Northland	*Taranaki*		*Waikato*		*West Coast*
	(Rawene)	*(Stratford)*	*(Waimate West)*	*(Hamilton)*	*(Matamata)*	*(Westport)*
Month:						
April	21	30	28	31	40	25
May	20	16	22	25	24	11
June	18	8	12	18	15	10
July	17	11	13	16	15	9
August	23	9	26	25	21	11
September	35	21	47	56	48	17
October	38	41	65	73	58	27

(2) Manawatu Dairy Pasture: *(Massey University[24])*

a) Total production:
- about 13,000 kg D.M./ha/year

b) Daily Growth:
- approximate growth-rate figures: (kg DM/ha/day)

Month:	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Growth:	25	20	30	45	60	65	45	35	30	20	30	25

(3) "Typical" New Zealand Dairy Pasture Growth Rates:
(strong ryegrass/white clover[25])

a) Total Production:
- about 10,000 to 12,000 kg D.M./ha/yr.

b) Daily Growth:
- approximate figures: (kg D.M./ha/day)

Month:	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Growth:	10	10	25	45	55	80	50	35	15	20	30	20

(4) "Potential" Pasture Production on New Zealand Dairy Farms:
Ryegrass/white clover pastures (dairy) have produced 17,000 to 18,000 kg D.M./ha/yr in grazing research, and yields of 13,000 to 14,000 kg D.M./ha/yr are regularly attainable on commercial farms[22].

2.10.4 Hill Country Pasture Growth Rates
(Note: See also Section 2.10.2)

(1) North Island Hill Country Pasture Growth Rates:

a) North Island hill soils[26]:

(i) Total production:

- about 11,400 kg D.M./ha/year on *Ash soils*; 8,200 kg D.M./ha/year on *Greywacke soils.*

(ii) Daily Growth:

- approximate figures (kg D.M./ha/day):

Month:	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Growth:												
Ash -	10	15	20	30	50	65	45	30	25	25	20	10
Greywacke -	10	10	20	30	45	45	35	25	15	15	10	10

b) "Average Northern North Island" hill soils[6]:

(i) Total production:

- approximately 8200 kg D.M./ha/year.

(ii) Daily Growth:

- approximate figures: (kg D.M./ha/day):

Month:	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Growth:	10	10	20	30	45	40	35	25	15	10	10	15

c) Manawatu improved (developed) hill country pasture[27]:

(i) Total production:

- about 8,000 kg D.M./ha/year.

(ii) Daily Growth:

- approximate figures: (kg D.M./ha/day)

Month:	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Growth:	5	5	15	40	55	50	60	45	35	35	25	15

(2) <u>South Island</u> Hill and High Country Pastures:
(See also Section 2.10.2)
Pasture production and growth patterns[19] for a variety of South Island hill and high country environments are stylised in Figures 1 to 4:

Figure 1: Dry/Cold Conditions
(Low Production)

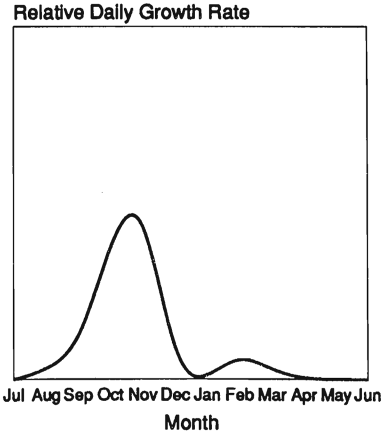


Figure 2: Dry/Warm Conditions
(Medium Production)

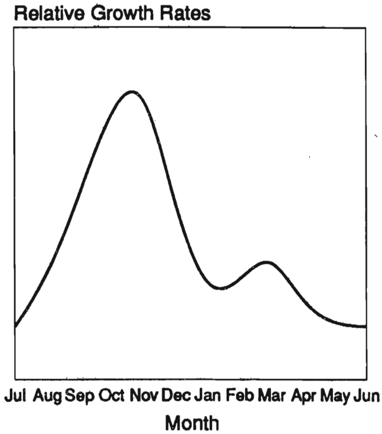


Figure 3: Cold/Wet Conditions
(Medium Production)

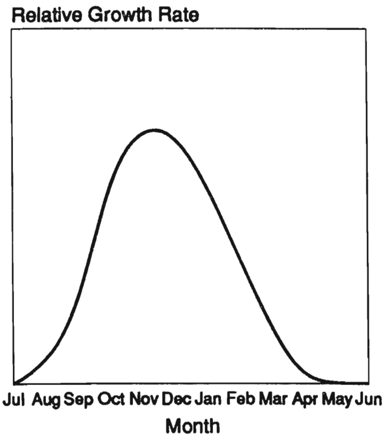
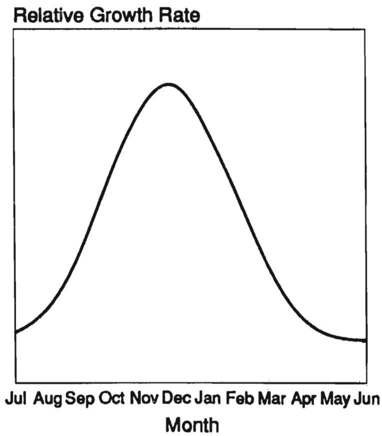


Figure 4: Warm/Wet Conditions
(High Production)



(3) Semi-Developed Hill Pastures:

a) *Effect of Development (Improvement) on Hill Pasture Production[6]:*

State of Pasture Improvement:	Kilograms of DM per hectare produced in:				Total Year's Production:
	Winter	Spring	Summer	Autumn	
Unimproved	170 (3%)	2240 (40%)	2410 (43%)	780 (14%)	5600 kg
Improved	940 (8%)	5670 (48%)	3300 (28%)	1890 (16%)	11800 kg
Highly Improved	1810 (12%)	6640 (44%)	4380 (29%)	2270 (15%)	15100 kg

Note 1: Unimproved pastures produce significantly less feed through the critical cool season.

Note 2: In some development situations, annual production may be less than a quarter of that of fully developed pastures - see also "Influence of Environment", over page.

b) *Unimproved Manawatu Hill Pasture:*

(i) Total production:

- about 5000 to 6000 kg D.M./ha/year[27].

(ii) Daily growth:

- approximate figures: (kg D.M./ha/day)

Month:	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Growth:	5	5	5	10	20	40	40	15	10	15	10	5

(4) Impact of Sunny/Shady Aspect on Hill Pastures:

a) *Impact on Annual Production:*

Whether the paddock faces to the north or south ("sunny" or "shady") can have a large influence on pasture production. Sunny paddocks will tend to produce more pasture per year (than shady) in districts which have adequate rainfall though the main growing season, but less (than shady) in districts prone to summer dry conditions. The difference in total production per year between sunny and shady paddocks can range from nil to 100%, depending mainly upon the relative differences in soil moisture and temperature levels. See *Table 3* over page for examples.

b) *Impact on Seasonal Production:*

Sunny paddocks tend to produce comparatively more (than shady) pasture through the late autumn/winter/early spring months. Conversely, shady paddocks tend to produce comparatively more (than sunny) through the late spring/summer/early autumn.

Table 3: Annual Production from Improved Pasture on North and South Aspects[29]

Figures are in kg D.M./ha/year:

Site:	***North (Sunny)***	***South (Shady)***	***Rainfall***
Whatawhata, Hamilton*	9960	9940	*1600 mm*
Te Kuiti*	4530	3880	*1450 mm*
Te Awa, Palmerston North (Suckling 1959)	9740	9070	*1060 mm*
Coopers Creek, Oxford*	2370	4220	*1070 mm*
Hunua, North Canterbury (White, unpublished)	2100	4190	*650-750 mm*

* *Radcliffe, 1971.*

(5) Influence of Slope/Steepness on Hill Pastures:

Pasture production on hill country is closely related to the steepness of the paddock, and is complicated by the effect of stock transferring fertility from the steep sidelings to "easy" stock camp areas.

a) In one trial, pasture production was 14,800 kgDM/ha/yr on the stock camps, but this reduced to 8,200 kgDM/ha/yr on the steepest parts of the same paddock[6].

b) From a north-facing paddock at Whatawhata (Hamilton), annual production per hectare varied as follows [6]:

Stock camp	*25^{o} slope*	*45^{o} slope*
11,100 kg D.M.	8,600 kg D.M.	5,400 kg D.M.

(6) Influence of Environment:

Measured pasture production on hill country has ranged from as little as 1000 to 2000 kg D.M./ha/yr through to 15,000 kg or more. Production is related to the harshness or kindness of the environment (as measured by altitude/temperature, rainfall/moisture, wind/exposure, soil conditions), as well as by pasture species, grazing management, and fertiliser applications.

2.10.5 Canterbury Dryland/Irrigated Pasture Production[21] Winchmore, Ashburton - see also Section 2.10.2.

(1) Dryland Pasture Production: (kg D.M./ha)

a) ***Production per month:***
(Results from 1960 to 1985)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Average:	210	212	223	890	1588	1043	474	374	308	457	400	258
Least:	51	31	31	518	820	0	0	0	0	35	57	42
Most:	499	590	590	1725	2437	2296	1302	1358	1444	1461	1236	602

b) ***Annual (and Seasonal) Production:***
(i) 1960/61 to 1984/85 :-

	Winter	Spring	Summer	Autumn	Total
Average -	646	3522	1157	1115	6442
Least -	113	1936	0	262	3904
Most -	1679	5785	3208	2669	9845
	kgDM/ha/yr				

(ii) 1985/86 to 1988/89 :-

1985/86 - 11234 kg D.M./ha
1986/87 - 7832 kg D.M./ha
1987/88 - 8436 kg D.M./ha
1988/90 - 2983 kg D.M./ha

(2) Irrigated Pasture Production: (kg D.M./ha)
(Irrigated at 21 day intervals or longer, depending on rainfall/soil moisture)

a) ***Production per month:***
(Results from 1960 to 1985)

	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Average:	209	204	217	948	1754	1632	1527	1418	1177	1055	629	332
Least:	40	30	30	407	1262	1224	931	937	743	595	237	48
Most:	477	525	525	1410	2248	2478	2389	1940	1755	1578	1307	766

b) ***Annual (and Seasonal) Production:***
(from 1960 to 1985)

	Winter	Spring	Summer	Autumn	Total
Average -	631	4335	4122	2017	11107
Least -	100	3291	2695	1094	7581
Most -	1527	6003	5450	3001	13430
kgDM/ha/yr					

2.10.6 <u>Pasture Growth and Management</u>
(Source: M.A.F.)

The S-shaped pasture growth curve (Figure 5.) shows the three phases of regrowth after grazing:

Phase 1 is the slow growth phase after very hard grazing. Most of the leaf has been eaten and the amount of photosynthesis is low because much of the sunlight is falling on bare ground or dead leaves.

Phase 2 is the period of most rapid growth. Most sunlight falls on green leaf and photosynthesis is high. This phase may be delayed after hard grazing but it can start almost immediately after light grazing.

Phase 3 is the period when accumulation of grass slows as the pasture length increases and more leaves become shaded. The death rate of plant tissue at the bottom of the sward starts to increase and in some cases may exceed the rate of plant growth. The proportion of dead and low quality feed becomes high. (See also Figure 6, over page).

Figure 5: Pasture Regrowth After Grazing Showing the Three Phases of Growth.

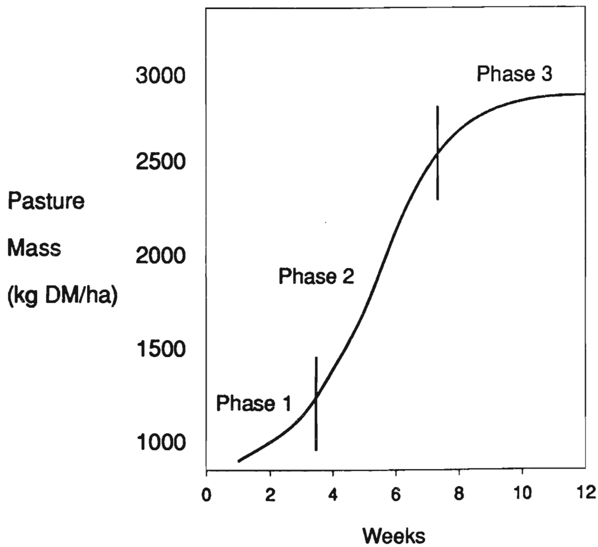
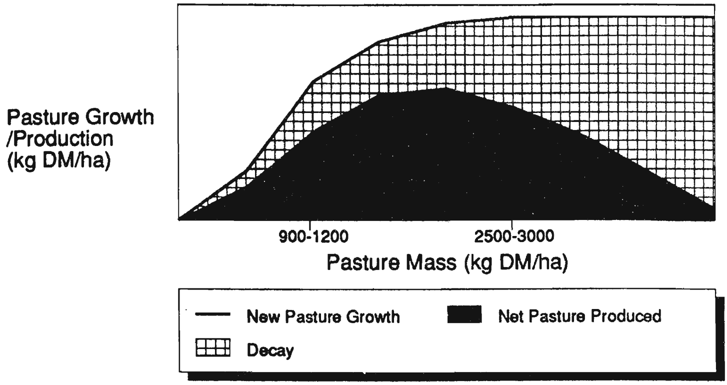


Figure 6: Effect of pasture mass on the rates of pasture growth, decay and *net* production.[28]



Implications of Grazing Management:

Keeping the pasture closely grazed can quite severely reduce pasture growth rates. These effects are minimal when pasture cover or mass is 1000 kg DM/ha or greater, but below that level can be significant. For example at a pasture cover of 800 kg DM/ha, pasture growth is only 85% of the potential, and at 600 kg DM/ha is less than 70%.

So, if pastures are grazed down below 1000 kg DM/ha they need an adequate spell from grazing to allow them to recover to above 1000 kg DM/ha. This avoids a prolonged reduction in pasture growth.

2.11 PASTURE MINERAL DEFICIENCIES AND REQUIREMENTS

2.11.1 Essential Elements for Plant Growth

(Source: Dr. K.C.Cameron, Soil Science Department, 1986)

There are 16 elements that are essential for the growth of plants. They are:

Carbon (C) Hydrogen (H) Oxygen (O)	These three elements are drawn from the air and water.
Nitrogen (N) Phosphorus (P) Potassium (K)	These three major elements are drawn from the soil. Nitrogen, in specific instances, is first fixed from the atmosphere by bacteria, e.g. in the case of legumes.
Sulphur (S) Calcium (Ca) Magnesium (Mg)	These three elements are the secondary elements.
Iron (Fe) Copper (Cu) Zinc (Zn) Manganese (Mn) Boron (Bo) Chlorine (Cl) Molybdenum (Mo)	These are the trace elements.

Growth and yield of crops are determined to a large extent by the nutrient element that is present in the smallest quantity to the plants' requirements.

2.11.2 Minerals : Plant Analysis and Standards

(Adapted from Cornforth and Sinclair[20])

There are two reasons for measuring the mineral content of plants. One is to check the nutrition of the plant itself and the other is to check the nutritive value of the plant to the animal that eats it. This section deals with the nutrition of the plant, alone. (Refer to Section 1.3.2 for stock requirements).

Plant composition depends on species and age of the plant, part analysed, weather, time of year when the sample is taken and the supply of nutrients from the soil. Even if the influence of all these factors is known, the picture is further confused by the effects of nutrient balance; too much or too little of one nutrient can influence the concentration of other nutrients in the plant.

Sampling Pasture or Crop:
Important: avoid soil contamination (especially in wet conditions). All samples should be clean, or washed thoroughly under a tap.

Grazed pastures should be sampled at grazing height (use clippers) to ensure that most of the material analysed is in a young, vegetative state. The clover should be separated from the grass (after sampling) and packed in separate bags, for separate analysis - *see Tables 4 and 5*, over page (mixed herbage samples are required for diagnosing *animal*, rather than *plant* nutrition problems - refer Section 1.3.2). With many crops the youngest fully expanded leaf is recommended as being both a sensitive and easily recognised tissue for sampling.

More sampling details appear with the tables for each crop.

Plant samples should be loosely packed in paper bags and dispatched to the analytical laboratory with the minimum delay. Avoid dispatch before weekends and holidays.

The interpretive standards listed in *Tables 4 to 7*, pages B-49 to B-51, refer to plants sampled under conditions apparently suitable for active growth; they do not apply to plants where growth is limited by physical conditions such as temperature or drought. Where possible, two samples should be submitted for analysis, one healthy and one suffering from the apparent deficiency. While this may ensure that the age and growing conditions of the two samples are comparable, care must also be taken that they are physiologically similar.

Interpretation of Analysis Results:
See Tables 4 to 7.

Note that, while a low nutrient concentration may limit plant growth, an apparently adequate concentration may not guarantee good growth.
Conversely, healthy crops may apparently have low levels of nutrients, due to a variety of circumstances.

Although there is a shortage of precise data on critical values for many nutrients and crops, there is more certainty about adequate nutrient concentrations. Thus plant analysis can be used to eliminate possible causes for poor growth with more confidence than it can positively identify deficiencies.

Table 4: *Standards for <u>White Clover</u> Leaf Chemical Analysis*

Plant part:	Leaves plus petioles (the slender stalks joining leaf blade to stem).
Stage of growth:	Grazing height
Other conditions:	Conditions conducive to active growth

Nutrient		Deficient	Low	Optimum	High
Nitrogen	N%	<4.4	4.4-4.7	4.8-5.5	>5.5
Sulphur	S%	<0.25	0.25-0.26	0.27-0.32	>0.32
Phosphorus	P%	<0.30	0.30-0.34	0.35-0.40	>0.40
Magnesium	Mg%	<0.15	0.15-0.17	0.18-0.22	>0.22
Calcium	Ca%	<0.3	0.3	0.4-0.5	>0.5
Potassium	K%	<1.7	1.7-1.9	2.0-2.4	>2.4
Manganese	Mn ppm	<20	20-24	25-30	>30
Zinc	Zn ppm	<12	12-15	16-19	>19
Copper	Cu ppm	<5	5	6-7	>7
Boron	B ppm	<20	20-24	25-30	>30
Molybdenum *	Mo ppm	<0.10	0.10-0.14	0.15-0.20	>0.20
Iron	Fe ppm	<45	45-49	50-65	>65
Nitrogen/ Phosphorus		>16	16-15	14-12	<12
Nitrogen/Sulphur		>20	20-19	18-16	<16

* *Note: Another text recommends topdressing with molybdenum, if the leaf analysis is less than* ***0.3****. Specialist advice should be obtained for the interpretation of analysis results. Molybdenum levels may also fluctuate according to the season, with high levels generally found in wet winter and early spring conditions, while low levels will be found during dry summer conditions (see also page B-52).*

Table 5: *Standards for <u>Ryegrass</u> Leaf Chemical Analysis*

Plant part:	Young, vegetative growth
Stage of growth:	Grazing height
Other conditions:	Conditions conducive to active growth

Nutrient		Deficient	Low	Optimum	High
Nitrogen	N%	<4.0	4.0-4.4	4.5-5.0	>5.0
Sulphur	S%	<0.22	0.22-0.26	0.27-0.32	>0.32
Phosphorus	P%	<0.30	0.30-0.34	0.35-0.40	>0.40
Magnesium	Mg%	<0.13	0.13-0.15	0.16-0.20	>0.20
Calcium	Ca%	<0.20	0.20-0.24	0.25-0.30	>0.30
Potassium	K%	<1.7	1.7-1.9	2.0-2.5	>2.5
Manganese	Mn ppm	<20	20-24	25-30	>30
Zinc	Zn ppm	<10	10-13	14-20	>20
Copper	Cu ppm	<4	4-5	6-7	>7
Boron	B ppm				>15
Molybdenum	Mo ppm	<0.15	0.15-0.29	0.30-0.40	>0.40
Iron	Fe ppm	<40	40-49	50-60	>60
Nitrogen/ Phosphorus		>15	15-14	13-11	<11
Nitrogen/Sulphur		>18	18-17	16-14	<14

Table 6: *Standards for <u>Cereal</u> Leaf Chemical Analysis*

Species:	Wheat, Oats, Barley
Plant part:	Whole above ground part
Stage of growth:	As head emerges from boot
Other conditions:	Conditions conducive to active growth

Nutrient		Deficient	Low	Optimum	High
Nitrogen	N%	<1.5	1.5-2.0	2.1-3.0	>3
Sulphur	S%		<0.15	0.15-0.40	>0.4
Phosphorus	P%	<0.15	0.15-0.20	0.21-0.50	>0.5
Magnesium	Mg%		<0.15	0.15-0.50	>0.5
Calcium	Ca%		<0.20	0.20-0.50	>0.5
Potassium	K%	<1.25	1.25-1.50	1.51-3.00	>3
Manganese	Mn ppm	<5	5-25	26-100	>100
Zinc	Zn ppm		<15	15-70	>70
Copper	Cu ppm		<5	5-25	>25
Boron	B ppm		<2	2-10	>10

Table 7: ***Standards for Maize Leaf Chemical Analysis***

Plant Part:	Earleaf
Stage of Growth:	Early silking
Other Conditions:	Take 20 leaves per paddock

Nutrient		Deficient	Low	Optimum	High
Nitrogen	N%	<2.00	2.00-2.24	2.25-3.30*	>3.30
Sulphur	S%	<0.10	0.10-0.12	0.13-0.25	>0.25
Phosphorus	P%	<0.15	0.15-0.17	0.18-0.32	>0.32
Magnesium	Mg%	<0.10	0.10-0.12	0.13-0.24	>0.24
Calcium	Ca%	<0.10	0.10-0.20	0.21-0.50	>0.50
Potassium	K%	<1.25	1.25-1.70	1.71-2.25	>2.25
Manganese	Mn ppm	<15	15-19	20-150	>150
Zinc	Zn ppm	<10	10-20	21-70	>70
Copper	Cu ppm	<2	2-5	6-20	>20
Boron	B ppm	<2	2-5	6-20	>20
Molybdenum	Mo ppm			0.10-0.50	

* *While large grain yields have been obtained with nitrogen concentrations at the low end of this range, other data suggests 2.8 to 3.4% N.*

2.11.3 Mineral Deficiency Symptoms in White Clover

Phosphorus Deficiency:
Plant growth is very dwarfed and dark green in colour. Old leaves become pale yellow and die. With time, all leaf stalks develop a slight purplish-pink colour.

Sulphur Deficiency:
Yellowing of all the leaves, often starting with the youngest.

Potassium Deficiency:
Variable symptoms:
(a) Summer: On the upper surface of the older leaves, numerous small white to pinkish-cinnamon coloured spots. Dead areas develop on the edges of these leaves and gradually spread until the whole leaf dies.
(b) Summer/Winter: On either side of the midribs of the oldest leaves, the development of dead areas on the leaf edges, beginning as pinkish-cinnamon spots.

Molybdenum Deficiency:
Stunted growth, general paleness of the plant (see also over page).

2.11.4 Molybdenum Deficiency

(Adapted from Cornforth and Sinclair[20])

Molybdenum plays an important role in nitrogen fixation by legumes. Severely molybdenum deficient plants are typically pale green to yellow in colour, have poor leaf formation and have stunted growth. Pastures lack vigour and revert to low fertility grasses. All these symptoms reflect the nitrogen deficient state of plant and soil.

Ed. Note: M.A.F. Aglink FPP 631 states that, apart from these symptoms, the diagnosis of molybdenum deficiency in pastures is difficult because plant tissue analysis is not always conclusive. Pasture samples should not be taken when soil is very wet or very dry, as Mo concentration in herbage varies with soil moisture (see page B-49). It is best to analyse pure clover samples. Both the molybdenum and nitrogen levels must be below optimum (see Table 4 page B-49) before response to applied molybdenum will occur.

Deficient Soils

The molybdenum status of New Zealand soil groups can be seen in Tables 8a (North Island soils) and 8b (South Island soils), on pages B-53 and B-54. This information is generalised.

Refer also to *Figure 7*, page B-55, which shows a map of the potentially deficient soils in New Zealand.

Table 8a: North Island Soils on which responses to Molybdenum have been recorded.
The degree of deficiency increases from being neither widely distibuted nor severe (1) to being both widely distributed and severe (3).

Soil Group	Average Annual Rainfall (mm)	Main Distribution	Degree of Deficiency
Yellow-Grey Earths	750-1000	Wairarapa	1
Yellow-Grey to Yellow-Brown Earth Intergrades	1000-1500	East Coast Wairarapa, Wanganui, Taihape	2
Yellow-Brown Earths	1000-1500	Wellington	2
Central Yellow Brown Earths and associated steepland soils	1000-1500	Manawatu, King Country	3
Northern YBE	1000-2000	Northland	3
Podzols	1250-2000		3
Brown Granular Loams & Clays	1250-1500	Waikato, Coromandel, Northland	2
Red and Brown Loams	1250-2000	Northland	2
Organic soils	1250-1500	Waikato, Bay of Plenty, Northland	*
Recent soils	750-2000		1

* *Mo required for initial development, but subsequently may be excessive.*

Table 8b: **<u>South Island soils</u> on which responses to Molybdenum have been recorded.**
The degree of deficiency increases from being neither widely distibuted nor severe (1) to being both widely distributed and severe (3).

Soil Group	Average Annual Rainfall (mm)	Main Distribution	Degree of Deficiency
Yellow-Grey Earths	550-900	Otago, Canterbury, Marlborough	2-3
Yellow-grey to Yellow Brown Earth Intergrades	750-1000	Southland, Otago, Canterbury, Marlborough	3
Lowland Yellow-Brown Earths	1000-1500	Southland	2
	1500-5000	West Coast	1
Central Yellow-Brown Earths (N.I. climate)	1000-1500	Nelson, West Coast, Marlborough Sounds	2
Upland Yellow-Brown Earths	750-1500	Otago, Canterbury, Marlborough	3
Well Drained Stony YGE	630-1000	Canterbury	2
Steepland YGE or YBE	630-1500	Malborough, Nelson,Canterbury, Otago and Southland	2
Gley Podzols	1800-5000	Nelson, West Coast*	1
Yellow-Brown Loams	1000-1500	Southland	1
Brown Granular Loams	400-1500	Otago, Canterbury, S'land, Nelson	2
Recent soils (except young and weakly weathered)	750-5000		1

* *Mo required for development only.*

The map in Figure 7 gives a generalised picture of distribution of potentially molybdenum deficient soils throughout New Zealand.
(Source M.A.F.).

Figure 7:

Topdressing with Molybdenum
On deficient soils, fifty grams of sodium molybdate per hectare* should be applied, every 4 years. This rate will correct molybdenum deficiency and give the maximum dry matter yield without producing dangerously high molybdenum concentrations in the herbage and associated stock health problems.

* *A rate of 50 g sodium molybdate/ha is achieved by :*
100 kg/ha of 0.05% Mo superphoshate (500 g sodium molybdate/tonne) or
250 kg/ha of 0.02% Mo superphoshate (200 g sodium molybdate/tonne).

Molybdenum, Sulphur and Copper Interactions
Primarily due to effects on copper absorption from the gut, the copper status of ruminants is adversely affected by high concentrations of molybdenum and sulphur in the feed. However, if the pasture is of normal copper status i.e. 6 to 10 ppm, it is extremely unlikely that applying molybdenum as recommended, will be the cause of any stock health problems.

It is of interest that small amounts of sulphate fertiliser are very important in preventing high concentrations of molybdenum in the herbage.

Lime and Molybdenum

The availability of molybdenum increases with a rise in soil pH. Thus lime may help to alleviate molybdenum deficiency and will increase the molybdenum concentration in the herbage. Care must be taken when applying molybdenum to soils of high pH as high concentrations of molybdenum in the herbage may result.

2.12 IDENTIFICATION OF GRASSES AND CLOVERS

2.12.1 Grasses [Reference: Lambrechtson N.A. "What Grass is That?"]

Name of Grass	Growth Habit	Ligule	Auricle	Hairs	Basal Sheath	Leaves In Bud	Special Botanical Features	Look for these Points
Perennial Ryegrass	Tufted	Short blunt	Present	Absent	Red	Folded	Leaves dull above, glossy below.	Red basal sheath, folded leaves in bud.
Italian Ryegrass	Tufted	Medium	Present	Absent	Red	Rolled	Lower leaf surface very glossy.	Red basal sheath, rolled leaves in bud.
Tall Fescue	As for Italian Ryegrass, but coarser throughout.							Edge of leaves rough.
Crested Dogstail	Tufted	Short Blunt	Absent	Absent	Yellow	Folded	Leaves dull above, glossy below.	Yellow basal sheath.
Meadow Foxtail	CU*	Short	Absent	Absent	Chocolate	Rolled	Dark Green - early spring grower.	Chocolate basal sheath.
Yorkshire Fog	Tufted or CA**	Ragged	Absent	Present	White sheath, red veins.	Rolled	Pale green thin soft hairy leaves.	Red veins on white basal sheath.
Timothy	Tufted	Long	Absent	Absent	White	Rolled	Swollen base to stem, blue-green leaves.	Swollen base to stem.

** CU = Creeping underground stems; ** CA = Creeping above.*

Name of Grass	Growth Habit	Ligule	Auricle	Hairs	Basal Sheath	Leaves In Bud	Special Botanical Features	Look for these Points
Cocksfoot	Tufted	Variable	Absent	Absent	White	Folded	Very flat shoot.	Very flat shoot, hairless.
Poa trivialis	CA**	Long Pointed	Absent	Absent	White	Folded	Two white lines down centre of leaf, leaf shiny below.	Creeping above ground, two white lines on leaf.
Poa pratensis	CU*	Small or absent	Absent	Absent	White	Folded	Two white lines down centre of leaf. Leaf semi glossy below.	Creeps below ground, (rhizomatous), lines on leaf.
Poa annua	CA or tufted	Large	Absent	Absent	White	Folded	Indistinct lines down centre of leaf, leaf dull below.	Creeps above ground, no rhizomes; dull short blades.
Danthonia pilosa	CU (slight)	Small	Absent	Present	White	Folded	Long narrow leaf. Tufts of long hairs at the collar.	Narrow long leaf, hairs at collar.
Sweet Vernal	CU or tufted	Large	Absent	Present	White	Rolled	Sweet smell, tufts of long hairs at collar.	Sweet smell, hairs at collar.
Doab or Bermuda Grass	CA	Hairy	Absent	Present	White	Folded	Grows on light dry soils. Tufts or long hairs at the collar.	Creeps above ground, hairs at collar.

** CU = Creeping underground stems; ** CA = Creeping above.*

Name of Grass	Growth Habit	Ligule	Auricle	Hairs	Basal Sheath	Leaves In Bud	Special Botanical Features	Look for these Points
Paspalum	CU*	Long	Absent	Present	White	Rolled	Broad reddish leaves, long hairs at collar. Stem swollen at base.	Red leaves, swollen stem, hairs at collar.
Browntop	CA**,CU	Short	Absent	Absent	White	Rolled	Leaf rough from tip to base.	Small ligule, rough leaf.
Red Top	CA,CU	Long or medium.	Absent	Absent	White	Rolled	Leaf rough from tip to base; a twitch.	A twitch. Larger ligule, rough leaf.
Creeping Bent	CA	Long pointed	Absent	Absent	White	Rolled	Leaf rough from tip to base, long pointed ligule.	Pointed ligule, rough leaf. Creeps above ground.
Old Man Twitch	CU	Short	Present	Present	White	Rolled	Leaves coarse, sheath hairy; a bad twitch.	Twitch with hairy sheath.
Prairie Grass	Tufted	Large	Absent	Present	White	Rolled	Broad light green leaves, very hairy sheath.	Very hairy sheath, light-green broad leaves.
Floating Sweet Grass	CA	Long & white	Absent	Absent	White	Folded	Leaf broad, soft and dull green. Leaf edges rough near tips.	Weak creeping stems when growing in shallow water.
Phalaris tuberosa (syn. aquatica)	CU or Tufted.	White, 12 mm long tapers to a blunt end.	Absent	Absent	Often pink.	Rolled	Leaf 10-40 cm long, 6-18 mm wide.	Very pronounced ligule.

** CU = Creeping underground stems; ** CA = Creeping above.*

Name of Grass	Growth Habit	Ligule	Auricle	Hairs	Basal Sheath	Leaves In Bud	Special Botanical Features	Look for these Points
Barley Grass	Tufted.	Short, blunt.	Present	Present	White	Rolled	Leaf hairy on both surfaces. Upper leaf sheaths may be hairless.	Auricles, hairy leaves.
Tall Oat Grass	Tufted.	Blunt, medium.	Absent	Present	White	Rolled	Leaf long and narrow with hairs in parallel lines. Leaf sheath may be sparsely hairy.	Roots chrome yellow.
Ratstail	CU* Tufted.	Absent	Absent	Present	White	Rolled	Leaf sheath hairy on upper part. Leaf dark green and narrow, hairy on lower margins.	Two tufts of hairs where auricle normally rises.
Chewings Fescue	CU Tufted.	Absent or short & blunt.	Absent	Absent	Pink	Folded	Leaves permanently rolled.	
Coarse Grass	Tufted.	Thin, short & slightly ragged.	Absent	Present	White	Rolled	Leaf thin and covered with fine hairs. Leaf sheath covered with long soft hairs.	

** CU = Creeping underground stems.*

2.12.2 Identification of Clovers

[*Reference: Healy "Identification of Weeds and Clovers".]

Name of Clover	Growth Habit	Stipule	Hairs	Leaf Shape & Markings	Flower	Special Botanical Features	Look for These Points
Red Clover	Mainly upright.	Large and attached to the stem for most of its length. Noticeably veined.	Usually very hairy.	Leaflets oval with white markings on upper surface.	Reddish Purple.	Leaflet veins much branched towards edge of leaf.	Oval leaflets, densely hairy on the back.
Alsike	Erect.	Green, with free ends drawn out to a long point.	Absent.	Leaflets toothed and obtuse at the apex.	Pink or almost white.	Veins on leaflets sparingly branched near the edge of the leaf.	Upright growing, without hairs.
White Clover	Prostrate.	White, membranous.	Absent.	Leaflets heart shaped.	Usually white, turn brown with age.	Moderate branching of leaflet veins at ends.	Spreads over ground, stems rooting at the nodes. Hairless.
Suckling Clover	Generally prostrate except where supported by other vegetation.	Broad green and pointed. Hairy on the margin.	Stem and leaves slightly hairy.	Leaflets broadest near the tip. Central leaflet is stalked.	Small yellow flowers with 12 or more florets which turn brown on fading.	Veins in leaflets unbranched.	Slender small leafed clover much branched at the base, central leaflet stalked.
Strawberry Clover	Prostrate.	Similar to white clover but larger and veining more prominent.	Absent or only sparsely present on upper part of leaf stalk.	Leaflets usually oval.	White with pinkish tinge swollen after flowering.	Leaflet veins close spaced and curving towards edge.	Strong overground stems rooting at the nodes.

Name of Clover	Growth	Stipule	Hairs	Leaf Shape & Markings	Flower	Special Botanical Features	Look for These Points
Subterranean Clover	Prostrate.	Broad with membranous edges indistinctly veined.	Present on leaves and stems particularly on under side of leaflets.	Leaflets usually heart shaped and dark markings on upper surface.	Usually 2-3 florets, white or pale pink. Turn down to the soil after flowering.	Leaflet veins few in number but branched slightly towards edges.	Hairy, prostrate clover with dark leaf markings.
Clustered Clover		Short but long pointed and toothed.	Usually hairless.	Leaflets egg shaped.	Small and pink flower, stalk absent.	Leaflet veins unbranched.	A slender hairless clover with egg shaped leaflets and toothed stipules.
Striated Clover	Prostrate to ascending.	Broad but ending in a fine point.	Conspicuously hairy.	Leaflets egg shaped.	Small and pink stalkless heads at end of stems in angles of leaf stalks.	Leaflet veins branched.	A slender hairy clover with egg shaped leaflets.
Haresfoot Trefoil	Erect.	Narrow, long pointed, reddish.	Hairy.	Leaflets long and narrow.	Silky round or elongated flower head.	Little or no branching in leaflet veins.	An upright stemmy and hairy clover with narrow leaflet.
Sweet Clover	Erect.	Narrow and sharp pointed.	Almost hairless.	Leaflets egg shaped, longest stalk on central leaflet margin toothed.	Flower head spike. Cultivated type white, wild varieties yellow.	Veins straight and almost unbranched.	Upright clover with narrow stalked leaflets.
Lotus Major	Weak, partly erect growth.	Replaced by two leaflets with mid ribs.	Sparsely hairy.	Oval and pointed. Middle leaflet stalk the longest.	5-12 florets in the flower. Rich yellow.	Few leaflet veins. Rather straggly, branching clover with paired stipules.	

Name of Clover	Growth	Stipule	Hairs	Leaf Shape & Markings	Flower	Special Botanical Features	Look for These Points
Lotus hispidus	Mainly erect.	Similar to *lotus major*.	Very hairy.	Usually smaller than *lotus major*.	2-4 florets in the flower. Yellow.	Leaflet veins few and straight.	Very hairy clover with paired stipules.
Burr Clover	Prostrate to ascending.	Large with fine conspicuous teeth.	Usually hairless.	Leaflets egg shaped. Some-times a black spot on each leaflet. Margin toothed at free end.	2-9 florets, yellow.	Leaflet veins straight with very little branching.	Rather prostrate clover, central leaflet on longer stalk and stipule finely divided.
English Trefoil or Black Medic	Prostrate with ascending tips.	Broad and tapering and generally toothed.	Hairy.	Leaflets heart shaped. Mid rib extends beyond leaf tip.	Round flower head. Yellow petals fall with age.	Leaflet veins straight, with very little branching.	Prostrate hairy clover. Leaflet mid rib extending beyond edge of leaflet.

2.13 IDENTIFICATION OF WEED SEEDS IN PASTURE SEED MIXTURES

See pages C-28 to C-31.

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SECTION 3

FORAGE AND CASH CROPS

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3.1 FORAGE CROPS

3.1.1 Information Provided and Further References.

This section provides some basic information on a number of summer and winter crops. This information should be used as a guide only - more detail may be obtained from various sources; including farm consultants, stock firms, and various texts; for example "Supplementary Feeding" (1980) - published by the N.Z.Society of Animal Production (C/- Ruakura Agricultural Research Centre, Private Bag, Hamilton.), and various M.A.F. "Aglinks" on specific crops.

Acknowledgement: Parts of this section were derived from a M.A.F. booklet "Fodder Crops" M.W. Auld - now out of print.

3.1.2 Forage Crop Husbandry

Refer to Tables 1 and 2 (pages C-7 and C-8) for specific sowing and harvesting data, and to Section 3.1.4 for further details on specific forage crops. Weed and pest control data for *cash* crops can be found in Section 3.2; some of this information will be applicable to Forage Crops.

General:

Sowing Seed with Fertiliser

Best results are usually obtained if the seed is drilled rather than broadcast. Soluble fertilisers e.g. Superphosphate, are likely to affect seed germination, if mixed with, or drilled close to the seed. Because of this it is safer to use reverted super, serpentine super or a proprietary crop fertiliser if the seed is to be sown with the fertiliser.

Sowing Dates

"Staggered" sowing dates may be necessary for crops that deteriorate quickly when mature, e.g. maize.

3.1.3 Stock Health Problems on Forage Crops

Refer to Section 3.1.4 for details on specific crops.

General:

Time Factor

It takes time for stock to adapt to being fed forage crops. To reduce digestive upsets, the crop should be introduced slowly to the animal's diet. The risk of health problems can be reduced by restricting grazing to 1 to 2 hours per day (less than this initially), making sure that the diet is balanced, and by watching stock closely.

Nitrate/Nitrite Poisoning

Fast growing (usually immature) crops can contain high levels of nitrate, particularly when the plants are recovering after a dry spell. In the animal this nitrate is converted to nitrite which, in large quantities, may cause death (symptoms are rapid breathing and staggers). The risk may be reduced by feeding crops when mature, and keeping stock off crop regrowth. Crops can be tested for nitrate levels (consult veterinarian).

3.1.4 Specific Forage Crops : Additional Information and Cautions

The *nutritive value* of specific forages is presented in Section 1.11.1
Note that the *yield* figures in Tables 1 and 2 (pages C-7 and C-8) do not account for any wastage of feed occurring at feeding off. Depending on the type of crop, grazing method and weather conditons, wastage can commonly range from 20 to 40 % (that is, only 60 to 80 % of the crop is utilised).

Brassicas:
(Refer also to Sections 3.1.2 and 3.1.3)

General
- *Choose aphid/virus resistant brassica varieties if available. Emerging seedlings are very susceptible to insect attack (particularly springtails); insecticide use is generally warranted, especially in drier years - refer also to Section 3.1.6. Use borated fertiliser (must not contact with seed) if "brownheart" is a problem (boron deficiency). Weed Control - see Section 3.1.6.*
- *Stock may take up to 4 to 5 weeks to adjust to a largely brassica diet, and initial performance may suffer accordingly, unless a balance of other feed is given.*
- *Brassica crops contain goitrogenic substances which affect the metabolism of iodine in stock. This is particularly so with kale, and is discussed below.*

Kale
A commonly grown variety is chou-moellier or marrow-stemmed kale. A number of varieties (see Section 3.2.1) are available for cattle and/or sheep. Fertile soils are usually preferred. Commonly grown for winter feed (see Table 2, page C-8), but can be sown earlier in spring for summer grazing. Ewes grazing kale for long periods during late pregnancy should receive supplementary iodine to protect against goitre in the lambs. Cattle grazing for more than 12 weeks may require copper supplementation (M.A.F. recommendation). A general recommendation is to finish feeding kale before flowering occurs, due to the occurrence of redwater in stock grazed on early spring growth. Kale anaemia may also occur as the crop matures and the nutritive value declines (woody stems).

Rape (and "Wairoa Brassica")
Rape is commonly grown for summer feed (see Table 1, page C-7), but can be sown in autumn, for winter grazing. Aphid resistant varieties include "Rangi", "Wairangi" and "Kentan". To avoid digestive upsets and "scald" (photo-sensitive reaction on ears and faces of stock), rape should not be grazed until mature (when leaves turn bronze or reddish blue/purple). Able to be grown on light, moderately fertile soils. "Wairoa brassica", which is more commonly grown in Northern areas, has a reduced risk of scalding and does not need to ripen as much as rape before feeding. However the plant is susceptible to aphids and clubroot. "Wairoa brassica" regrows well after grazing (up to 5 grazings). Further varieties - see Section 3.2.1.

Swedes
Prefer fertile free-draining soils. Susceptible to clubroot. High nutritive value, and ability to stand without deterioration over winter. Varieties resistant to aphid/virus include "Kiri", "Sensation", "Calder" and "Tina". Also see Section 3.2.1 for further varieties.

Turnips (Soft)
Able to be grown on light, moderately fertile soils. Turnips are highly digestible, but do not 'keep' as well as swedes in the winter. As with any root crop, only stock with sound teeth can harvest the bulbs efficiently, and significant tooth wear can occur due to soil intake. Young and aged stock can be given first 'pick' of the leaves. Feeding dairy cows immediately after milking will help avoid tainting the milk. Traditional varieties include "York Globe" (early maturing, fast growing) and "Green Globe" (slower growing but hardy). See Section 3.2.1 for further varieties.

Cereals - Oats/Barley for Greenfeed:
(Refer also to Sections 3.1.2 and 3.1.3)
Cereals can cope with less fertile soils than the ryegrasses (below). Cereals have extremely low levels of calcium, and this can create problems in young stock (rickets) and breeding stock in late pregnancy or lactation. As with ryegrasses, cereals are responsive to nitrogenous fertilisers, and can give problems with nitrate/nitrite poisoning (see 3.1.3). Sometimes spring sown with peas. Greenfeed oat varieties - see Section 3.2.1.
See also Ryecorn (page C-6).

Maize (Greenfeed):
(Refer also to 3.1.2 and 3.1.3).
Requires warm, moist, fertile soil conditions. Frost tender at all stages. Treated seed for disease. Responds to nitrogen and phosphorous fertilisers. Plant density and stage of grazing (best before tassel formation) critical for maximum digestibility and high yields. Low in protein and some minerals (best fed as part diet with pasture). Stagger planting dates (10 day intervals) to avoid all crop maturing at same time.

Dairy cows allowed to gorge themselves on relatively mature maize cobs can suffer from lactic acid poisoning (vomiting/scouring and eventual death). Hybrid varieties should be used if silage is required.

Ryegrasses (Annual/Biennial, for Greenfeed):
(Refer also to 3.1.2 and 3.1.3)
Perform best on fertile soils, and respond well to nitrogenous (N) fertilisers. Nitrate/nitrite poisoning may be a problem (see Section 3.1.3), paticularly with fast growing immature plants (N fertilisers may aggravate). Varieties: see Section 2.2.1.

Sorghum Hybrids:
(Refer also to 3.1.2 and 3.1.3)
Sorghum hybrids such as "Chowchow" (not to be confused with kale or choumoellier), require hot, moist, fertile soil conditions, and are therefore most suited to North Island regions with hot summer temperatures. Soil temperature at least 17°C, and rising, at sowing. Responds well to nitrogen fertiliser (also on regrowth). Must be mature for grazing (at least 0.5 metres high, preferably 1 metre). The regrowth (young leaf), particularly after drought, is high in Prussic Acid. If eaten by stock this results in cyanide poisoning and rapid death. Stunted plants also can pose a danger. Stock should be introduced slowly to the crop, and back-fenced to avoid danger of grazing regrowth. If in doubt, restrict grazing to approximately 20 minutes with careful observation (symptoms are staggering and laboured breathing).
Can be made into silage, but becomes woody and unpalatable if over-mature.

Other Forage Crops:
Lupins
Sowing Rate 35 to 100kg/ha, sow January (Information: Prof. J White, pers.comm.).

Ryecorn
Sowing Rate 135 to 200 kg/ha (70 kg with grass). Sow February for winter feed (Information: Prof. J White, pers.comm.).

Fodder Radish
Sowing rate approximately 6 to 10 kg/ha (spring sown for summer feed).

Also:
Fodder beet (spring sown for winter feed).
Mangolds (as for fodder beet).
Millet (sow late spring for summer feed).
Peas (spring sown, sometimes with oats).

Table 1: **Summer Forage Crops**
(Editors Note: Data presented in simplified form - use as guide only)

CROP:	Seeding Rate kg/ha (Drill or Broadcast)	Weeks to to first grazing (approx)	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	Yield * Dry Matter Kg/ha
Greenfeed Maize	120 - 130 (D) 150 - 160 (B)	10 - 14	North Is. South Is.									7000 - 13000 S.I. generally less than N.I.
Rape (also "Wairoa Brassica" - see page C-4)	2 - 3 (D) 4 - 5 (BC) (1 kg in mix)	10 - 13 (rape must be mature; see notes)										4000 - 5500 (some regrowth esp. Wairoa Brassica)
Sorghum Hybrid e.g. "Chowchow" (Hot/North Is.)	20 - 25 (D) 25 - 30 (BC)	6 + (must be mature; see page C-6)										6000 - 9000 (2-3 grazings)
Turnips (soft)	0.7 + (D) 1.1 + (BC) (x 2 for leaf bulk)	10 - 12										4500-6000

KEY:

Usual Sowing Time**

Usual Feeding Period

Arrows signify less usual times

* Yield: see Section 3.1.4, page C-4.
** Sowing times are extremely variable depending on the season, crop and intended use.

Table 2: **Winter Forage Crops**
(Editors Note: Data presented in simplified form - use as guide only)

CROP:	Seeding Rate kg/ha (Drill or Broadcast)	Weeks to to first grazing (approx.)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	Yield * Dry Matter kg/ha
Kale (or Chou., see Section 3.1.4)	2 - 4 (D) 4 - 5 (BC)	18 + (can be grazed earlier)				(Can regrow from earlier, light grazing)										6000 - 8000+
Ryegrasses Annual/biennial types	30 (Paroa 25)	6 +														3000 - 5000+ (several grazings)
Swedes	0.8 + (D) 1.2 + (BC)	20 +														5500 - 7500+
Turnips (soft)	0.7 + (D) 1.1 + (BC) (Lower rate if in seed mixture)	12 +	North Is. South Is.													4000 - 6000
Oats/Barley	100 - 120	10 +														3000 - 4000 (Limited regrowth)

KEY:

Usual Sowing Time**

Usual Feeding Period

Arrows signify less usual times

* Yield: see Section 3.1.4, page C-4.
** Sowing times are extremely variable depending on the season, crop and intended use

3.1.5 Estimating Forage Crop Dry Matter (D.M.)

(Note: Dry Matter is the weight of feed less the water content).

1. Choose a representative part of the paddock (away from the fencelines etc.), and harvest (cut) the crop from an area of at least 1 square metre (1m x 1m). A larger sample area (e.g. 2 square metres = 141 cm x 141 cm) is likely to give a more accurate estimate of crop yield; as will the harvesting of more than one sample and averaging the weights.

2. Weigh the forage (kg) and multiply the figure by 10 - this will give the fresh weight (water included) of the crop, in tonnes per hectare. For example, a turnip crop may weigh 5 kg (sample weight) x 10 = 50 tonnes per hectare. (If the sample area is 2 square metres, multiply by a factor of 5).

3. Refer *Section 1.11.1* for an estimate of the crop's percentage dry matter (% D.M.). For example, turnips would probably average 10% D.M. from tops and bulbs combined (see also *Note A*, below). Multiply this figure by the fresh weight (from 2. above), and again by 10 to obtain the dry matter yield of the crop, expressed in kilograms of D.M. per hectare.

For example, with turnips:

Tonnes of fresh weight per hectare (50) x %D.M. (10) x 10 = 5000 kg D.M./ha*

- A further example is for, say, greenfeed maize:

1 square metre sample weight = 4.3 kg.
Therefore fresh weight (Tonnes/ha) = 4.3 x 10 = 43 tonnes/ha
Estimate of Percent Dry Matter (see *Section 1.11.1*) = 23%
Therefore estimated dry matter yield of the crop is:

43(T) x 23 (%) x 10 = 9890 kgD.M./ha*

* *The dry matter figure does not take account of wastage which will take place when the crop is harvested by stock or machinery. Commonly, stock may utilise only 60 - 80% of the total crop offered to them (see Section 3.1.4).*

Note A: With root crops such as turnips and swedes, more accurate estimates can be made if the leaves are weighed separately from the bulbs. This is because the percentage dry matter of the bulb is different to that of the leaf. Thus two different fresh weights and percentage dry matter figures will be multiplied out (see 2. and 3. above) to derive the kgD.M./ha of each of the components.

3.1.6 Weed and Pest Control in Forage Brassicas

For the use of chemicals in general, precautions and toxicity levels, refer to Sections 2.7.1 and 2.7.2.

Weed and pest control data for forage brassicas is contained in Tables 3(a) and 3(b), pages C-10 and C-11.

Table 3(a): <u>Weed Control in Forage Brassicas</u>

Weed	Chemical (a.i.)	Examples of Product	Application Rate of Product (<u>Not</u> a.i.) *(Manufacturer's <u>Minimum</u> Recommendation)*
Broad Leaf Weeds	dicamba	Dicamba 20	700 ml/ha
	chlornitrofen	Fodderkleen	4-5 litres/ha
	desmetryn	Semeron 25 WP	1 kg/ha (Choumollier)
	trifluralin	Treflan	2-3 litres/ha (pre-establishment) up to 6 weeks prior to sowing
Californian Thistle	clopyralid amine salt	Versatill	0.5 litres/ha
Grasses	fluazifop-P-butyl	Fusilade	1-3 litres/ha depending on grass to be controlled.

Table 3(b): <u>Pest Control in Forage Brassicas</u>

Pest	Chemical (a.i.)	Examples of Product	Application Rate of Product (<u>Not</u> a.i.) *(Manufacturer's <u>Minimum</u> Recommendation)*
Aphids	chlorpyrifos	Chlorpyrifos 48 EC	300 ml/ha
		Lorsban 40 EC	350 ml/ha
	dichlorvos	Dichlorvos 100 E	350 ml/ha
		Nuvam 1000 EC	350 ml/ha
	disufoton	Disyston 10	10 kg/ha
	thiometon	Ekatin	800 ml/ha
	fenitrothion	Caterkill 60, Verthion EC	1 litre/ha
	omethoate	Folimat	700 ml/ha
	maldison	Maldison, Malathion	3 litres/ha

"Continued on page C-11"

Pest Control in Forage Brassicas (Cont.)

Pest	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Aphids (continued)	demeton-S-methyl	Metasystox	800 ml/ha
	phorate	Phorate, Thimet 20G	5 kg/ha
	mevinphos	Phosdrin	0.5 litres/ha
	pirimicarb	Pirimor 50	250 g/ha
	dimethoate	Rogor E	800 ml/ha
Springtails	terbufos	Lorsban 40 EC	250 ml/ha
		Counter 20G	3 kg/ha
	diazinon	Diazinon 800	350 ml/ha
		Gesapon 80 EC	350 ml/ha
	disufoton	Disyston 10	10 kg/ha
	fenitrothion	Caterkill 60, Verthion EC	1 litre/ha
	maldison	Maldison 50, Malathion 50	600m ml/ha
	phorate	Phorate, Thimet 20G	5 kg/ha
	dimethoate	Rogor E	800 ml/ha
Weevils	terbufos	Counter 20G	3 kg/ha
	fenitrothion	Caterkill 60, Verthion EC	1 litre/ha
White Butterfly and	dichlorvos	Dichlorvos 100E	350 ml/ha
Diamond Back Moth		Nuvam 1000EC	350 ml/ha
-caterpillars	permethrin	Ambush 50 EC	100 ml/ha
	maldison	Maldison	3 litres/ha
	mevinphos	Phosdrin	1 litre/ha

3.2 CASH CROPS

3.2.1 Recommended Varieties

Wheat
Canterbury:
Spring - Otane and Lancer
Winter - Amethyst, Norseman, Pegasus, Saphire, Temuka, Waiau, Weka.
Southland: Spring - Otane
North Island: Spring - Otane
Speciality: Konini (purple grain) and Tara (durum)

Barley
Malting: Triumph.
Feed:
Canterbury - Magnum, Fleet, Koru, Liberty, Illia (6 row winter)
Lower North Island - Georgie, Goldmarker, Kym
Otago, Southland - Georgie, Universe, Regatta

Oats
Milling: Makuru, Ohau
Feed Grain and Chaff: Makuru, Taiko, Amuri, Omihi
Greenfeed: Amuri, Algerian, Winter grey, Duns

Ryecorn
Rahu, Dominant.

Maize
Double hybrids (numerous).

Peas
Maple: Whero
Blue: Rovar, Morehu
White: Huka
Garden: Pania, Bolero, Patea, Tere, Kuru, Apex, Minder, Waka
Marrowfat: Maro

Lentils
Titore, Laird, Olympic

Lupins
Uniharvest, Unicrop.

Potatoes
Ilam Hardy, Rua, Sebago, Katahdin, Iwa.

Rape
Rangi, Moana, Wairangi, Giant, Winfred (winter feed).

Swedes
Doon Major, Doon Spartan (aphid resistant),
Wilhelmsburger, Calder and Sensation (drought and aphid resistant), late
Kiri (clubroot resistant).

Turnips
Purple and Green Top (yellow),
Green and York Globe (early),
Manga (clubroot resistant),
Kapai (aphid resistant),
Stubble turnips (various).

Kale
Maris Kestrel, Medium Stemmed (sheep),
Giant (cattle).

Lucerne - See Section 2.4.1

Ryegrass - See Section 2.2.1 plus various amenity ryegrasses

Cocksfoot - See Section 2.2.2

Phalaris
Maru

Prairie Grass
Matua

Tall Fescue - See Section 2.2.4 plus various amenity tall fescues

Clovers - See Sections 2.3.1 to 2.3.3

Lotus
Maku.

Chicory
Puna

Paspalum
Raki

Timothy
Kahu

3.2.2 Sowing and Harvesting of Cash Crops

(Refer to Section 3.2.1 for varieties of these crops)*

Crop*	Plant Population (pl/m^2)	Sowing Rates kg/ha	Row Width & Depth	Sowing Dates	Harvesting Dates
Barley	200 Autumn 250 to 300 Spring	120 - 200 (depends on seed size)	15 cm rows	April to May (winter barley); late August/October normally; November on heavy land.	January to February
Cocksfoot		3 - 5	30 cm rows 1 - 2 cm deep	February to early March	Early January.
Field Peas	60 - 120	200 - 300 (depends on seed size)	15 cm rows 5 - 6 cm deep	May September to October	January to February
Garden Peas	90 Dryland 120 Irrigated	200 - 350 (depends on seed size)	15 cm rows 5 - 6 cm deep	August to November	Dec to early Feb for processing. Jan to Feb for seed crops.
Green Beans	38	90 - 100 according to seed size	38 cm rows 5 to 6 cm deep	November to early January	February to April
Lentils	150 (autumn) 150 - 250 (spring)	60 - 200 according to seed size	15 cm rows 3 - 4 cm deep	May preferably, or August to early September	early January
Lupins		Seed: 135 - 200	15 cm rows 5 cm deep	April or September/October for seed.	December to February

Crop*	Plant Population (pl/m^2)	Sowing Rates kg/ha	Row Width & Depth	Sowing Dates	Harvesting Dates
Maize	6	Seed 30	60 cm rows 5 cm deep	October to early November	April to June (seed)
Oats	250 Autumn 300 (Spring S'land)	100 - 180 depends on seed size	15 cm rows 5 cm deep	May August to September	January to February February to March
Potatoes	4 - 5	1500 of 30 - 55 g seed (1 - 2 oz) 2500 of 55 - 95 g seed (2 - 4 oz)	75 cm rows 10 cm deep 30 cm apart	October for main crop in South Island. August to October in Manawatu; May to July in Pukekohe.	March to June in South Island. December to May in Manawatu; August to November in Pukekohe
Red Clover	45 - 60	5	15 cm rows 1 - 2 cm deep	February to March with ryegrass; August to October with spring crops.	March to May.
Ryegrass	500 - 600 250	20 for most; 30 for Tama & Moata.	15 cm rows 1 - 2 cm deep	Late February to March	Late December to early January.
Wheat	200 to 250	100 - 200 (depends on seed size)	15 cm row 5 cm deep	May to June August to September October	January to February February to April (Southland)
White Clover	60 in 30 cm rows	3.0	30 cm rows 1 - 2 cm deep	February to March with ryegrass; May with wheat; August to October with spring crops. February after crop harvest.	January to February.

(Refer to Section 3.2.1 for varieties of these crops)*

References "Arable Management Recommendations" M.A.F 1986/87
"Pastures - Their Ecology and Management", Langer 1990.

3.2.3 Weed Control in Cash Crops

(For use of chemicals in general refer to Sections 2.7.1 and 2.7.2)

Weed	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Broad leaf			
- pre-emergence	trifluralin	Treflan	Cereals, O.S. Rape and Peas: *1.5 to 2 litres/ha*
- post-emergence	bromoxynil and ioxynil	Axall	Wheat, Barley and Oats: *2 to 2.5 litres/ha*
	diflufenican and isoproturon	Cougar	*1 litre/ha*
	dicamba	Dicamba	Oil Seed Rape: *500 ml/ha*
	dichlorprop	Duplosan DP	*2 litres/ha* Barley, Oats, Ryecorn and Wheat.
	mecroprop-p	Duplosan KV	*1.5 litres/ha* Not where W.Clover is undersown.
	chlorsulfuron	Glean	Cereals: *20 g/ha* (plus wetting/spreading agent)
	MCPA potassium salt	MCPA	Cereals: *3 litres/ha* (not for use when undersown with legume)
	MCPB sodium salt	MCPB	Cereals and Peas: *3 litres/ha*
	MCPA, mecoprop, dicamba and dichlorprop	Salvo	Wheat, Barley, Oats and Ryecorn: *3 litres/ha*
Wild Oats	triallate	Avadex	Wheat, Barley, Peas: *3.5 litres/ha*
	difenzoquat	Avenge	Cereals: *1.5 kg in 200 to 300 litres of water/ha*
	L-flamprop isopropyl + xylene	Commando	Wheat, Barley, Oats: *4 litres/ha*
	tralkoxydim	Grasp	Wheat and Barley: *1.5 litres/ha with mineral oil as spray adjuvant*
Grasses	clethodim	Centurion 240EC	*250 ml/ha*
	haloxyfop	Gallant	Peas: *1.2 litres/ha*
Thistles/Yarrow	clopyralid amine salt	Versatill	(Cereals) *300 to 500 ml/ha*

3.2.4 Insect Control in Cash Crops

(For use of Chemicals in general refer to Sections 2.7.1 and 2.7.2)

Pest	Chemical (a.i.)	Examples of Product	Application Rate of Product (Not a.i.) *(Manufacturer's Minimum Recommendation)*
Aphids	chlorpyrifos	Chlopyrifos 48EC	300 ml/ha
		Lorsban 40EC	300 ml/ha
	diazinon	Diazinon 80 EC	800 ml/ha
	dichlorvos	Dichlorvos 100 E	350 ml/ha
		Nuvam 1000 EC	350 ml/ha
	disufoton	Disyston 10	10 kg/ha
	thiometon	Ekatin	800 ml/ha
	omethoate	Folimat	800 ml/ha
	methomyl	Lannate L	1.5 litres/ha
	demeton-S-methyl	Metasystox	600 ml/ha
	dimethoate	Perfecthion S	560 mls/ha
	phorate	Phorate, Thimet 20G	5 kg/ha
	mevinphos	Phosdrin	600 ml/ha
	taufluvalinate	Maverik Aquaflow	150 ml/ha (Oil Seed Rape)
	pirimicarb	Pirimor 50	200 g/ha
	dimethoate	Rogor E	700 ml/ha
Army Caterpillars	dichlorvos	Dichlorvos 100E, Nuvam 1000E	300 ml/ha
	fenitrothion	Caterkill 60, Verthion EC	800 ml/ha
Cutworm	methomyl	Lannate L	1.5 litres/ha
Grass Grub	methomyl	Lannate L	1.5 litres/ha
		Counter 20G	3 kg/ha down drill
	phorate	Phorate, Thimet 20G	5 kg/ha

3.2.5 Disease Control in Cash Crops

Most crop diseases can be placed conveniently into three groups based on their main method of spread; from crop to crop and from season to season. The three groups are as follows:

- Seed-borne
- Air-borne, including splash dispersal and spread by insects
- Soil-borne

Information on these aspects of the life cycle of plant diseases is essential in determining the strategies that can be used for their control.

In considering control programmes, there are four aspects of importance:

1. Reduce or eradicate the sources of plant diseases. This is primarily concerned with hygiene, and is based on the old adage that "prevention is better than cure". Rotation of crops is also important here.

2. Where practical, alter the environment (soil, crop and storage) in favour of the host plant, so reducing the chances of diseases becoming established and/or slowing down their rate of spread in crops.

3. Use resistant cultivars. Most plant breeding programmes have, as one of their aims, the development of new cultivars that are more resistant to diseases than those they are to replace. This is the best method of control and for many diseases there are good resistant cultivars.

4. Protection of the host plant:
   There has been some success with the use of biological control of plant diseases, i.e. using a non-pathogenic species to inhibit or retard the development of disease-causing organisms.

   In general it is still necessary to rely on chemicals for protection. These are applied in a number of ways to crops, e.g. as seed treatments, as sprays or dusts, and as granules (often applied into the soil). The chemicals that are available are of three types:

   Protectant - applied to outside surfaces of the plant and interfere with infection of the plant by pathogens (disease-causing organisms); for example, copper oxychloride, captan, thiram.

   Eradicant - these, as well as protecting, have limited movement into the plant to eradicate established infections, e.g. dodine (Melprex 40, etc.) used for black spot control in apples.

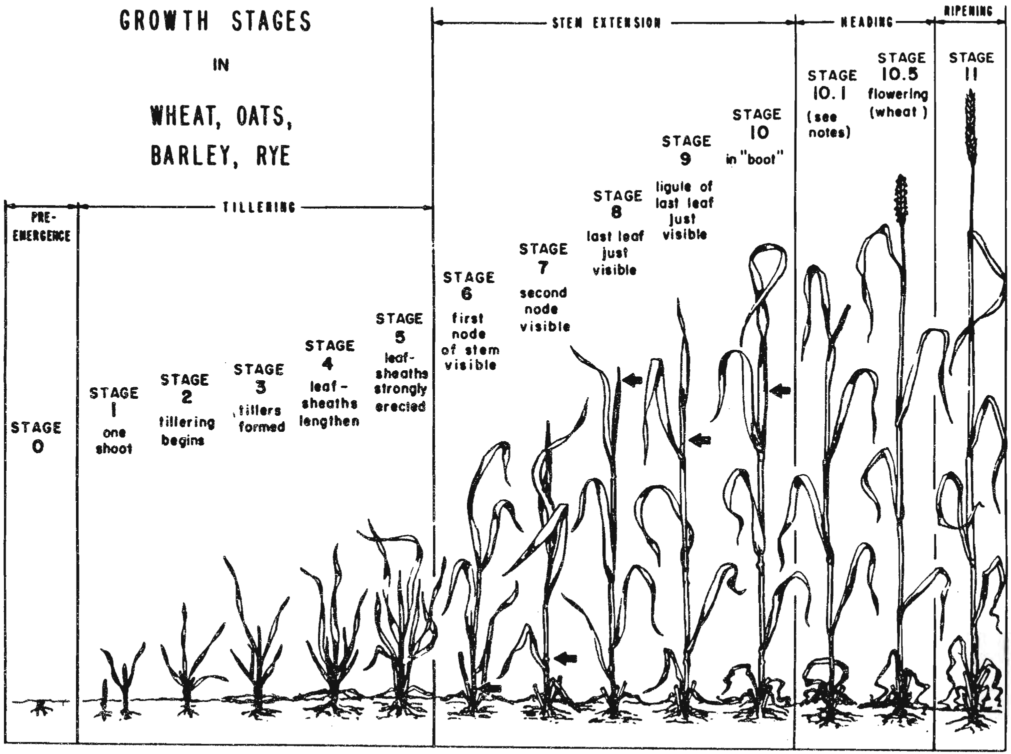
   Systemics - these have been developed since 1965, and will act as both protectants and eradicants, as well as being able to move through the plant in an upward direction in the xylem, or water transport pathway. There are a number of different compounds available, e.g. benomyl, carboxin, thiabendazole, propiconazole, etc.

There are two difficulties associated with the use of systemics. Most have a narrow spectrum of activity inhibiting some fungal organisms and not others. Thus it is essential to know the range of organisms that are affected by each, and in order to obtain effective control of two or more diseases it may prove necessary to use mixtures of two systemics, or mixtures of a systemic with a protectant. The other disadvantage of systemics is that a number of fungal organisms can develop resistance to their action. This breakdown of effectiveness can be avoided by a number of methods such as alternating the use of a systemic with a protectant, or using systemics from different groups.

NOTE 1: The various chemicals used in plant disease control are tabulated in Sections 3.2.6 to 3.2.10. The list is not complete and the use of alternative chemicals should be discussed with your local advisory people (chemical company representatives, advisors etc.), as well as considering the correct time of application of sprays for maximum control of diseases. With all chemicals READ THE LABEL for notes on rates of use and hazards associated with their use. See also Sections 2.7.1 and 2.7.2 for use of chemicals in general and toxicity levels.

NOTE 2: In order to explain control of cereal diseases it is necessary to understand the growth stages of cereals. This diagrammatic key is reproduced on the following pages.

GROWTH STAGES IN WHEAT, OATS, BARLEY, RYE



GROWTH STAGE KEY FOR CEREALS

(Sometimes referred to as the Feekes Scale)

	Stage
1	One shoot (number of leaves can be added) = "brairding".
2	Beginning of tillering.
3	Tillers formed, leaves often twisted spirally. In some varieties of winter wheats, plants may be "creeping" or prostrate.
4	Beginning of the erection of the psuedo-stem, leaf sheaths beginning to lengthen.
5	Pseudo-stem (formed by sheaths of leaves) strongly erected.
6	First node of stem visible at base of shoot.
7	Second node of stem formed, next-to-last leaf just visible.
8	Last leaf visible, but still rolled up, spike beginning to swell.
9	Ligule of last leaf just visible.
10	Sheath of last leaf completely grown out, spike swollen but not yet visible.
	10.1 First spikes just visible (awns just showing in barley, spike escaping through split of sheath in wheat or oats).
	10.2 Quarter of heading process completed.
	10.3 Half of heading process completed.
	10.4 Three-quarters of heading process completed.
	10.5 All spikes out of sheath.
	10.5.1 Beginning of flowering (wheat)
	10.5.2 Flowering complete to top of spike
	10.5.3 Flowering over at base of spike
	10.5.4 Flowering over, kernel watery ripe
11	11.1 Milky ripe.
	11.2 Mealy ripe, contents of kernel soft but dry.
	11.3 Kernel hard (difficult to divide by thumbnail).
	11.4 Ripe for cutting. Straw dead.

(After E.C. Large, 1954. Plant Pathol. 3:128 to 129).

3.2.6 Seed-borne Diseases in Cereals (including Maize)

All cereal grain for sowing should be treated with ar approved fungicide.

Seed Treatments for Cereals

Trade Name	Control
Baytan I M (triadimenol 15%)	**Wheat:** seed-borne loose smut and stinking smut; soil-borne Fusarium; early protection against air-borne powdery mildew and rusts (mainly stripe rust; leaf rust epidemics are normally later after systemic action has dissipated.) **Barley:** seed-borne loose smut, covered smut, leaf stripe, net and spot blotch, and scald; soil-borne Fusarium; early protection against air-borne powdery mildew and rust. **Oats:** Seed-borne loose and covered smuts, and soil-borne Fusarium.
Benlate (benomyl 50%)	Loose smut of wheat
Vincit (Flutriafol 5% + imazalil sulphate 5%)	**Wheat:** Seed-borne loose smut, stinking smut, stripe rust, Fusarium. **Barley:** Seed-borne loose and covered smut, net and spot blotch, leaf stripe and scald, Fusarium. **Oats:** Seed-borne loose and covered smut, crown rusts, seedling blight, soil-borne seed and seedling rots.
Vitaflo 200 (carboxin 20%, thiram 20%)	**Wheat:** seed-borne loose smut and covered smut; spot blotch; soil-borne seed and seedling rots. Including Fusarium. **Barley:** seed-borne loose and covered smut; net and spot blotch; leaf stripe (only in spring-sown crops). (Soil-borne diseases as for wheat.) **Oats:** seed-borne loose and covered smut; leaf spot; seedling blight (Drechslera spp.); leaf stripe. (Soil-borne diseases as for wheat.) **Maize:** Head Smut (Soil-borne diseases as for wheat).

The purpose of seed treatment is to control disease organisms on or in the seed, as well as to protect the seedlings against soil-borne pathogens. Some fungicides, e.g.

Baytan IM can protect against some air-borne pathogens (e.g. powdery mildew, and rusts), when these are present in the young crop.

The diseases that must be controlled by seed treatment are the stinking and covered smuts, and where loose smut is a problem, a systemic product should be used, such as Vitaflo 200, Baytan IM, or Vincit, or Benlate.

In barley net blotch can be serious, but in general it is effectively controlled by the use of Vitaflo 200 or Baytan IM or Vincit.

In maize, head smut (both seed and soil-borne) is partially controlled by seed treatment using carboxin + thiram (Vitaflo 200). In fields with high levels of smut alternative crops can be grown to reduce levels of smut in soil.

3.2.7 Air-borne Diseases of Cereal Crops (including Maize)

Barley yellow dwarf virus (BYDV) spread by the cereal aphid.

Wheat - autumn-sown - sow in late May or early June to avoid the aphid flights.

Spring (September) sown wheat - BYDV is of much less importance, though in some trials yield losses have been prevented by the use of a granular O.P.(organo-phosphate) insecticide at sowing followed six weeks later by an O.P. spray.

Barley - because of its faster growth rate, seems much less affected by BYDV. However, virus-infected plants can sometimes be seen markedly yellow in colour and scattered throughout crops.

Oats - sown in autumn for greenfeed, are often severely infected, showing the typical reddish-purple colouration of the leaves. Infected plants often contain high levels of nitrate which may affect health of grazing stock. Oats, sown for grain, when infected show blasting of the head.

Stripe Rust:

This occurs only in wheat. Seed of susceptible cultivars must be treated with Baytan IM or Vincit to protect seedling plants against infection and thus delay epidemic development. Infection still can occur in crops, and they should be treated with a suitable systemic fungicide spray* as soon as stripe rust is detected. In May-sown crops, this is generally in early October. A further spray may be required in early to mid-November. An alternative control is to use resistant cultivars (e.g. Kotare, Konini, Kokart).

**Suitable fungicides - Cereous, Impact, Tilt 250 EC, Corbel, Mistral.*

Leaf Rust:
Can appear late in wheat or barley crop growth (at or after flowering). Grain size is reduced, because the leaf area is less, and so there is less assimilates for the grain. If more than 50% of the flag leaf and leaf 2 are infected at this stage (G.S. 10.5 to 10.5.4, see pages C-20 and C-21) then the crop should be sprayed with suitable rust fungicides:
Suitable fungicides - Cereous, Impact, Tilt 250 EC, Corbel, Mistral.

Stem Rust:
This also occurs late in crop development - infecting the stem below the ear and reducing the movement of water and assimilates to the developing grain. Stem rust is not often a problem in New Zealand, but in some seasons and in some localities spraying with suitable rust fungicides may be necessary.

Speckled Leaf Blotch:
Can occur early in growth of autumn (May-June) sown wheat. Spray from early to late August when the disease can be found infecting at least half the first leaves of seedling wheat. Best time of application is probably G.S. (Growth Stage) 3 to 4, using Benlate, Baviston FL, Cereous, Sportak 45EC or Tilt 250EC. This also can occur later in crop development (at flowering) when sprays for leaf rust control will provide control. As the fungus survives on crop debris, burn or destroy wheat stubble as soon as possible after harvest.

Powdery Mildew:
Occurs on wheat and barley, though the races on each are distinct, the one on wheat will not infect barley and vice versa. In susceptible cultivars some losses of yield have been detected. However trials have shown that spraying only for mildew control is not always economical. With some cultivars spraying may be worthwhile, use Tilt 250EC, Benlate, Calixin or other chemicals effective against mildew.

Net Blotch of Barley:
Mainly controlled through the use of effective seed treatment chemicals. However, the disease also can spread into barley crops from outside sources such as stubble and volunteer plants. These sources must be destroyed before spring sowing of barley commences. A fungicide spray during crop growth can be beneficial ; use Tilt 250EC, Impact, Sportak 45EC.

Maize - Northern leaf blight:
A common disease, generally severe in some areas of the Waikato causing losses in yield. The fungus survives in the debris from the previous crop, so plough stubble early to reduce this carry over of disease. Resistant cultivars are an effective means of control.

3.2.8 Summary of Chemical Control of Airborne Diseases in Crops

Tables 1(a) and (b) show the chemicals available for control of air borne diseases in cereal crops - see Sections 2.7.1 and 2.7.2 for chemical use in general, and Section 3.2.5.

Table 1(a)

Chemical Name:	Alto IOL*	Bavistan	Benlate	Calixin	Cereous	Corbel or Mistral	Delsere 50 DF
Active Ingredient:	10% cyproconazole	50% carbendazin	50% benomyl	70% tri demorph	25% tridemenol	75% fenpropimorph	50% carbendazin
Application Rate/ha:	400 ml	300 ml	500 g	700 ml	500 ml	1 litre	500 g
Disease Controlled							
Crown Rust (Oats)					YES		
Stripe Rust					YES	YES	
Leaf Rust	YES				YES	YES	
Speckled Leaf Blotch		YES			YES		
Scald (Barley)		YES			YES	YES	YES
Northern Leaf Blight							
Net Blotch Barley							
Powdery Mildew			YES	YES	YES	YES	

* Alto IOL: This chemical has an Experimental Use Permit only (as at November 1990).

Note: see Table 1(b), page C-26, for further chemicals.

Control of airborne diseases (Continued):

Table 1(b)

Chemical Name:	Folicur	Impact	Mancozeb (Dithane)	Maneb M22	Sportak 45 EC	Tilt 250 EC
Active Ingredient:	terbuc-conazole	12.5% flutriafol	80% Mancozeb	80% Maneb	45% prochloraz 35% xylene	25% prop-iconzole
Application Rate/ha:	750 ml	1 litre	2 kg	2 kg	1 litre	500 ml
Disease Controlled						
Crown Rust (Oats)	**YES**					**YES**
Stripe Rust	**YES**	**YES**				**YES**
Leaf Rust	**YES**	**YES**				**YES**
Speckled Leaf Blotch	**YES**				**YES**	**YES**
Scald (Barley)	**YES**	**YES**				
Northern Leaf Blight			**YES**	**YES**		
Net Blotch Barley	**YES**	**YES**			**YES**	**YES**
Powdery Mildew	**YES**	**YES**				
Ovularia	**YES**					

3.2.9 Soil-borne Diseases of Crops

1. **Take-all** - in wheat and barley (and couch/twitch):
   Rotate crops, burn or destroy stubble. Avoid areas where couch is present or has been killed by Roundup.

2. **Eyespot** - in wheat:
   Can be a problem in 2nd or 3rd crops. Rotate crops, burn or destroy stubble, good weed control, sowing rate less than 150 kg, use of partially resistant cultivars. (Kokart, Weka).
   Chemical - spray Benlate or Bavistan FL at G.S. 7 to 8. (See growth stage key, pages C-20 and C-21).

3. **Root Rots of Maize:**
   May be severe in some areas. Such areas should not be used for future maize sowings.

3.2.10 References:

Close, R.C. and Harvey, I.C. 1987: "Cereal Seed Treatment" available from Lincoln University Bookshop, 112 pp.
"Management of Pests and Diseases: Cereals 1990-91" available from Plant Protection Centre, MAFQual, P.O. Box 24, Lincoln.

3.2.11 Chemical Use in Conservation Tillage

Grass Weeds

Chemical	
Amitrole	Rates depend on weeds present, and stage of growth
Roundup (glyphosate)	
Spraygrow (paraquat and diquat)	

Clovers/Broadleaved weeds

Chemical	
Granstar*	Mixture with Roundup
Dicamba 20/Banvel 200 (contains dicamba)	
Versatill (clopyralid amine salt)	

* *Granstar: methyl 2-[3-(4-methoxyl-6-methyl-1,3,5-trazin-2-yl)-3-methylureido sulphonyl]benzoate))*

3.2.12 Plant Analysis to Determine Mineral Deficiency in Crops

Refer to Section 2.11.2

3.2.13 Buying Seed: Identifying the weed seeds/impurities from information provided on the seed analysis certificate.

(Source: M.A.F.)

In New Zealand-grown seedlots a number of other crop or weed seeds may be found. A list, using both botanical and common names, is given of the species likely to occur.

Seed buyers should be aware of the risk of introducing unwanted weeds on to their properties through the use of contaminated seedlots.

They should identify the weed impurities by looking at the seed analysis certificate, find the botanical names of the species present, and use the following table to provide, if required, the common name accepted in New Zealand.

Botanical Name	Common Name	Botanical Name	Common Name
Acacia sp.	wattle	*Betula sp.*	birch
Acaena anserinifolia	piri piri	*Bidens sp.*	beggars' tick; cobblers' pegs
Acaena ovina	Australian sheep's bur		
Achillea millefloium	yarrow	*Bothriochloa decipiens*	pitted blue grass
Agropyron repens	couch grass	*Brassica sp.*	wild turnip
Agrostis capillaris	browntop	*Brassica tournefortii*	mediterranean mustard
Agrostis sp.	bent	*Briza maxima*	quaking grass
Aira caryophyllea	silvery hairgrass	*Briza Minor*	shivery grass
Allium triquetrum	three cornered garlic	*Bromus mollis*	soft brome
Allium vineale	wild onion	*Bromus sterilis*	barren brome
Alopecurus geniculatus	kneed foxtail	*Bromus willdenowii*	Prairie grass
Alopecurus mysouroides	black grass	*Bulbinella hookeri*	Maori onion
Alopecurus pratensis	meadow foxtail	*Bupleurum sp.*	slender hare's-ear
Alternanthera philoxeroides	alligator weed	*Calandrinia sp.*	calandrinia
Amaranthus sp.	amaranth; redroot	*Camelina sativa*	false flax
Ambrosia artemisiifolia	annual ragweed	*Campanula sp.*	campanula
Amphibromus neesii	swamp wallaby grass	*Capsella bursa-pastoris*	shepherd's purse
Amsinckia calycina	yellow gromwell	*Cardaria draba*	hoary cress
Anagallis arvensis	scarlet pimpernel	*Carduus nutans*	nodding thistle
Andropogon sp.	andropogon	*Carduus tenuiflorus*	Winged thistle
Anthemis arvensis	corn chamomile	*Carex longebrachiata*	Australian sedge
Anthemis cotula	stinking mayweed	*Carex sp.*	Sedges
Anthoxanthum odoratum	sweet vernal	*Carrichtera annua*	Ward's weed
Anthriscus sylvestris	cow parsley	*Carthamus lanatus*	saffron thistle
Aphanes arvensis	parsely piert	*Carum carvi*	caraway
Apium sp.	wild celery	*Cassia sp.*	cassia
Arctotheca calendula	capeweeed	*Centaurea cyanus*	cornflower
Argemone ochroleuca	mexican poppy	*Centaurea solstitialis*	yellow star thistle
Aristida sp.	wire grass	*Centaurium sp.*	centaury
Arrhenatherum elatius	tall oat grass	*Cerastium sp.*	mouse-ear chickweed
A. elatius var. bulbosum	onion twitch	*Chenopodium album*	fathen
Asphodelus fistulosus	asphodel	*Chloris acicularis*	curly windmill grass
Aster sp.	michaelmas daisy	*Chloris gayana*	Rhodes grass
Aster subulatus	sea aster	*Chloris truncata*	windmill grass
Atriplex sp.	salt bushes, orache	*Cichorium sp.*	Chicory, endive
Avena fatua	wild oat	*Cirsium arvense*	Californian thistle
Avena sativa	oat	*Cirsium vulgare*	Scotch thistle
Axonopus sp.	carpet grass	*Claytonia perfoliata*	miner's lettuce
Axyris sp.	pigweed	*Clematis sp.*	clematis
Barbarea sp.	winter cress	*Collomia sp.*	collomia
Bellis perennis	daisy	*Conium maculatum*	hemlock
Beta vulgaris	beet	*Conringia orientalis*	hare's ear mustard

Convolvulus arvensis	Field bindweed
Conyza sp.	fleabane
Coprosma sp.	Coprosma
Coriaria sp.	tutu
Coronilla varia	crownvetch
Coronopus didymus	twin cress
Coronopus squamatus	wart cress
Cotula sp.	cotula; soldier's button
Crepis capillaris	hawkesbeard
Crotalaria sp.	crotalaria
Cuscuta epithymum	clover dodder
Cuscuta sp.	dodder
Cynodon dactylon	indian doab
Cynosurus cristatus	crested dogstail
Cynosurus echinatus	rough dogstail
Cyperus sp.	sedges
Cytisus scoparius	broom
Dactylis glomerata	cocksfoot
Datura stramonium	thorn apple
Daucus carota	wild carrot
Deschampsia caespitosa	tufted hair grass
Desmodium sp.	tick clover
Deyeuxia avenoides	mountain oat grass
Dianthus armeria	Deptford pink
Dicanthum sericeum	Queensland bluegrass
Dichelachne crinita	long-hair plume grass
Digitalis purpurea	foxglove
Digitaria sp.	summer grass
Diplotaxis muralis	wall rocket
Dracocephalum parviflorum	American dragonhead
Echinochloa crus-galli	barnyard grass
Echinochloa utilis	Japanese millet
Echium plantagineum	Paterson's curse
Echium vulgare	viper's bugloss
Eleocharis sp.	spike rushes
Elusine indica	crowfoot grass
Emex australis	spiny emex
Epilobium sp.	willow herb
Eragrostis cilianensis	stink grass
Eragrostis sp.	bay grass
Erechtites sp.	fire weed
Erigeron annuus	white-top
Eriochloa sp.	cup grass
Erodium botrys	long storksbill
Erodium cicutarium	storksbill
Erodium moschatum	musky storksbill
Eruca vesicaria	rocket
Erysimum sp.	treacle mustards
Eschscholzia californica	Californian poppy
Euphorbia peplus	milkweed
Euphorbia sp.	spurge
Euphrasia sp.	eyebright
Festuca arundinacea	tall fescue
Festuca pratensis	meadow fescue
Festuca rubra	Chewings fescue, red fescue
Fimbristylis sp.	fimbristylis
Foeniculum vulgare	fennel
Fragaria sp.	wild strawberry
Fumaria sp.	fumitory
Galega offcinalis	goat's rue
Galeopsis tetrahit	hemp nettle
Galinsoga parviflora	galinsoga
Galium aparine	cleavers
Galium mollugo	hedge bedstraw
Galium divaricatum	slender bedstraw
Gentiana sp.	gentian
Geranium dissectum	cut-leaved geranium
Geranium molle	dove's foot
Geranium pusillum	small-flowered geranium
Geranium robertianum	herb-Robert
Geum sp.	geum
Glaucium flavum	horned poppy
Glyceria sp.	sweet grass
Gnaphalium sp.	cudweed
Hainardia cylindrica	barb grass
Haloragis erecta	shrubby haloragis
Heliotropium europaeum	common heliotrope
Hibiscus sp.	hibiscus
Hieracium sp.	hawkweed
Hirschfeldia incana	hoary mustard
Holcus lanatus	yorkshire fog
Holcus mollis	creeping fog
Hordeum vulgare	barley
Hordeum murinum	barley grass
Hydocotyle sp.	hydrocotyle
Hypericum sp.	St John's wort; tutsan
Hypochoeris glabra	smooth catsear
Hypochoeris radicata	catsear
Juncus bufonius	toadrush
Lachnagrostis filiformis	N.Z. windgrass
Lactuca sp.	wild lettuce
Lagurus ovatus	harestail
Lamium sp.	henbit; dead nettle
Lapsana communis	nipple wort
Leontodon autumnalis	autumn hawkbit
Leontodon taraxacoides	hawkbit
Lepidium campestre	field cress
Lepidium sp.	narrow-leaved cress
Leptospermum scoparium	manuka
Lespedeza sp.	lespedeza
Leucanthemum vulgare	ox-eye daisy
Linaria vugaris	toadflax
Linum bienne	Australian flax
Linum cartharticum	purging flax
Linum usitatissimum	linen flax and linseed
Lithospermum arvense	corn gromwell
Lolium temulentum	darnel
Lolium sp.	ryegrass
Lotus corniculatus	birdsfoot trefoil
Lotus suaveolens	hairy birdsfoot trefoil
Lotus uliginosus	lotus
Lupinus sp.	lupins
Luzula sp.	wood rushes
Lycium sp.	boxthorn
Lythrum hyssopifolia	loosestrife
Malva sp.	mallow
Marrubium vulgare	horehound
Matricaria matricarioides	rayless chamomile
Matricaria perforata	scentless chamomile
Medicargo arabica	spotted bur medick

Medicargo lupulina	black medick	*Ranunculus parviflorus*	small-flowered buttercup
Medicargo polymorpha	bur medick	*Ranunculus repens*	creeping buttercup
Medicargo sativa	lucerne	*Ranunculus sardous*	hairy buttercup
Melilotus alba	sweet clover	*Ranunculus sceleratus*	celery-leaved buttercup
Melilotus indica	King Island melilot	*Raphanus raphanistrum*	wild radish
Melinis minutiflora	molasses grass	*Rapistrum rugosum*	turnip weed
Mentha pulegium	penny royal	*Reseda lutea*	cut-leaved mignonette
Microlaena stipoides	meadow rice grass	*Reseda luteola*	wild mignonette
Modiola caroliniana	creeping mallow	*Romulea rosea*	onion grass
Montia sp.	dwarf montia	*Rubus fruticosus*	blackberry
Myosotis sp.	forget-me-not	*Rudbeckia hirta*	black-eyed Susan
Nasturtium sp.	water cress	*Rumex acetosella*	sheep's sorrel
Navarretia squarrosa	california stinkweed	*Rumex sp.*	dock
Nepeta cataria	catmint	*Rumex obtusifolius*	broad-leaved dock
Nicandra physalodes	apple of Peru	*Rytidosperma sp.*	danthonia
Oenothera stricta	sand primrose	*Sagina sp.*	pearlwort
Onobrychis viciifolia	sainfoin	*Salsola kali*	saltwort
Ornithopus perpusillus	wild serradella	*Saliva reflexa*	mintweed
Ornithopus sativus	serradella	*Saliva verbenaca*	wild sage
Orobanche minor	broom rape	*Sambusus nigra*	elder
Oxalis sp.	oxalis	*Sanguisorba minor*	sheep's burnet
Panicum sp.	witchgrass	*Scabiosa sp.*	scabious
Papaver rhoeas	field poppy	*Schoenus sp.*	bogrush
Papaver somniferum	opium poppy	*Scirpus sp.*	club-rush
Parapholis incurva	sickle grass	*Scleranthus sp.*	scleranthus
Parentucllia viscosa	tarweed	*Secale cereale*	ryecorn
Paspalum dilatatum	paspalum	*Selliera radicans*	selliera
Pastinaca sativa	wild parsnip	*Senecio jacobaea*	ragwort
Pennisetum clandestinum	kikuyu grass	*Senecio vulgaris*	groundsel
Phacelia sp.	phacelia	*Sesamum indicum*	sesame
Phalaris aquatica	phalaris	*Setaria sp.*	bristle grass
Phalaris arundinacea	reed canary grass	*Sherardia arvensis*	field madder
Phalaris canariensis	canary grass	*Sida sp.*	sida
Phalaris minor	lesser canary grass	*Silene pratensis*	white campion
Phalaris paradoxa	gnawed canary grass	*Silene gallica*	catchfly
Phleum pratense	timothy	*Silene noctiflora*	night-flowering catchfly
Phlox sp.	phlox	*Silene vulgaris*	bladder campion
Physalis peruviana	cape gooseberry	*Silybum marianum*	variegated thistle
Phytolacca octandra	inkweed	*Sinapis alba*	white mustard
Picris echioides	ox tongue	*Sinapis arvensis*	charlock
Pisum sativum	pea	*Sisymbrium officinale*	hedge mustard
Plantago coronopus	buck's horn plantain	*Sisymbrium orientale*	oriental mustard
Plantago lanceolata	narrow-leaved plantain	*Sisyrinchium iridifolium*	purple-eyed grass
Plantago major	broad-leaved plantain	*Solanum nigrum*	black nightshade
Poa annua	annual poa	*Soliva sp.*	Onehunga weed
Poa pratensis	kentucky bluegrass	*Sonchus arvensis*	perennial sow thistle
Poa trivialis	rough stalk meadow grass	*Sonchus asper*	prickly sow thistle
Polycarpon sp.	allseed	*Sonchus oleraceus*	sow thistle
Polygonum aviclare	wireweed	*Sorghum bicolor*	sorghum
Polygonum cornvolvulus	cornbind	*Sorghum halepense*	Johnson grass
Polygonum hydropiper	water pepper	*Sorghum sudanense*	Sudan grass
Polygonum lapathifolium	pale willow weed	*Spergula arvensis*	spurrey
Polygonum persicaria	willow weed	*Spergularia maritima*	sea spurrey
Polypogon monspeliensis	beard grass	*Spergularia rubra*	sand spurrey
Portulaca oleracea	wild portulaca, purslane	*Sporobolus africanus*	ratstail
Potentilla norvegica	norwegian cinquefoil	*Stachys arvensis*	stagger weed
Potentilla recta	tall cinquefoil	*Stellaria graminea*	stitchwort
Prunella vulgaris	selfheal	*Stellaria media*	chickweed
Psoralea sp.	psoralea	*Stipa trichotoma*	nassella tussock
Puccinellia sp.	salt grass	*Stipa sp.*	needle grass
Ranunculus flammula	spearwort	*Stylosanthes sp.*	stylosanthes

Taraxacum officinale	dandelion
Teucrium botrys	cut-leaf germander
Thlaspi arvense	penny cress
Torilis nodosa	hedgehog parsley
Trianthema sp.	pigweed
Trifolium arvense	haresfoot trefoil
Trifolium campestre	hop trefoil
Trifolium dubium	suckling clover
Trifolium fragiferum	strawberry clover
Trifolium glomeratum	clustered clover
Trifolium hybribum	alsike clover
Trifolium incarnatum	crimson clover
Trifolium micranthum	lesser suckling clover
Trifolium ornithopodioides	trigonel
Trifolium pratense	red clover
Trifolium resupinatum	reversed clover
Trifolium repens	white clover
Trifolium striatum	striated clover
Trifolium subterraneum	subterranean clover
Triticum aestivum	wheat
Triticum durum	durum wheat
Ulex europaeus	gorse
Urtica sp.	nettle
Vaccaria parviflora	cow cockle
Valerianella sp.	corn salad
Verbascum sp.	mullein
Verbena officinalis	vervain
Veronica sp.	speedwell
Vicia faba	broad bean; tick bean; horse bean
Vicia sp.	vetches
Viola arvensis	field pansy
Vulpia sp.	vulpia hair grass
Wahlenbergia sp.	harebell
Xanthium spinosum	Bathurst bur
Zea mays	maize, sweet corn

SECTION 4

FERTILISERS, LIME, SOILS.

Compiled by

P.H. Fleming, Farm Management Department
(Sections 4.1 to 4.7 inclusive, and 4.9)

Dr K.C. Cameron, Soil Science Department (1986)
(Sections 4.8 and 4.10).

4.1 PHOSPHATIC FERTILISERS

4.1.1 Major Phosphatic Fertilisers: Super, Longlife, R.P.R.

Phosphorus Content and Availability[1]

The most important phosphatic (P) fertilisers, by volume of sales in New Zealand, are Superphosphate, Longlife and Reactive Phosphate Rocks (R.P.R.). Features of these fertilisers are as follows (B.O.P. Fertiliser Co. Ltd.):

	Super	Longlife *(see Note A below)*	R.P.R.
Total Phosphorus (P) content in the fertiliser:	9 %	10 %	13 % *(see Note B)*
Proportion of the P which is readily dissolved:	92 %	58 %	7 % *(see Note C)*
Availability of Phosphorus for pasture use:	Readily Available	Intermediate	Slowly Available
Total Sulphate (S) content in the fertiliser:	12 %	8 %	1 %

Note A: Longlife generally consists of 70% (by weight) Superphosphate and 30% R.P.R.[1]

Note B: It is recommended that farmers check the phosphorous content of R.P.R. at time of ordering, as the content may vary with different shipments[2]*.*

Note C: Because of the relatively low solubility of the phosphorous in R.P.R. in normal conditions (see below), it takes 3 to 4 years before all of it becomes available for plants to use (this also accounts for the "intermediate"/medium availability of the phosphorous in Longlife).

Selecting the Most Suitable Phosphatic Fertiliser

Of the three fertiliser types described above, R.P.R. is currently (1990) the cheapest source of phosphorous, when measured in terms of cost per kg of total phosphorous[3]. However it is not a suitable source of P in all situations. Current recommendations are that R.P.R. will work best when the soil pH level is less than 6.0 (some sources recommend less than 5.5) and annual rainfall is more than 800 mm (approximately 32"). The lower the pH, and the higher the rainfall, the faster the R.P.R. will dissolve. Because Longlife fertiliser contains approximately 30% R.P.R., soil pH levels and rainfall will also affect its performance to some degree.

Where soil P (phosphorous/phosphate) levels are low, R.P.R. (and to some extent, Longlife), may not be the ideal fertiliser to use. For example, if there is a need to quickly increase or "boost" the pasture production from a soil with low P levels, Superphosphate is probably the best fertiliser to use (P is readily available). Again, where soil P levels are low (Olsen P test less than 10), but the farmer wishes to only maintain the pasture production at its current level, there is some suggestion[2] that it would be best to continue using Superphosphate (or possibly Longlife), as a source of P, because R.P.R., with a slower rate of release, is likely to cause a drop (probably small) in pasture production, at least in the short term (approximately 2 years).

Where soil P levels are adequate, any of the three fertiliser types would be suitable to maintain pasture production, provided other soil factors such as sulphur levels, pH and rainfall (see page D-3) are satisfactory.

Further Information on R.P.R. and Longlife fertilisers

Soils tests taken after a number of years of R.P.R. fertiliser use may show disappointingly low P levels (M.A.F. Olsen P test). This is apparently the fault of the soil test, not the fertiliser, and M.A.F. are currently developing a new system for assessing the level of P in the soil, which takes into account the undissolved R.P.R.[1]

The three major R.P.R. fertilisers on the market (in 1990) are "Sechura", "North Carolina" and "Egyptian"[1]. Each has a total P level of approximately 13% (by weight of fertiliser), and a "Citric Soluble P" level of 30 to 40%. (M.A.F. criteria for direct application is that this figure should be more than 30%). MAFTech scientists are of the opinion that all three types are likely to perform similarly.

Many N.Z. soils require fertilisers containing sulphur (S). As R.P.R.s do not contain significant quantities of sulphur (see table on page D-3), elemental S can be blended in with the fertiliser. To be effective, the elemental S must be finely ground. M.A.F.'s current recommendation is that farmers should check with their fertiliser company* that the particle size of the elemental S is correct for their situation[3]. For most regions (annual dressings), the particles should be smaller than 250μm (0.25 mm), and for dry, cold regions, smaller than 150μm (0.15mm).

* *Note: M.A.F. emphasize the importance of obtaining this information before purchase, because apparently much of the elemental S sold in N.Z. is too coarse, and higher application rates may be required.*

Although adding S will increase the cost of R.P.R. fertilisers, the cost per hectare (using 1990 prices) will be less than that for Superphosphate in most situations[3]. Longlife fertilisers (which contain moderate levels of sulphur - see table on page D-3), also usually cost less than Superphosphate (per hectare).

Longlife fertilisers allow incorporation of potash and trace elements, and retain the granulated properties of Superphosphate (R.P.R.s by contrast are generally fine, sandy products and require care in transport and spreading).

In some situations in the South Island it may be possible to topdress every 2 to 3 years with R.P.R. (at higher rates per hectare), and gain further cost efficiencies[2].

4.1.2 P.A.P.R. Fertilisers (Partially Acidulated Phosphate Rock)

These fertilisers have a higher phosphorous content (about 15%) than R.P.R., and in field trials have been shown to be universally effective[4]. Sulphur, potash and trace elements can be added, and the product is well granulated. Unfortunately, cost savings are not so great as with R.P.R. because of the expense associated with the phosphoric acid used in the manufacturing process.

4.1.3 Measuring the "Plant Available" P in Superphosphate based Fertilisers (The Citric Solubility Test)

[Note: The following does not apply to Reactive Rock Phosphates (R.P.R.)]

Not all of the phosphorous (P) to be found in Superphosphate - based fertilisers becomes available for pasture plants to use. A "citric solubility" test carried out on the fertiliser gives the best estimate of "plant available" phosphorous. With good quality Superphosphate, over 90% of the total P is "plant available". In the past however, some N.Z. superphosphates have had a citric solubility as low as 80%.

Example:

	Total Phosphorous Content (9%) per tonne of Super	*Citric Soluble* Phosphorous per tonne of Super
Superphosphate:		
- Good Quality		
(90% of total P is cit. sol.)	90 kg	81 kg (8%)
- Poor Quality		
(80% of total P is cit. sol.)	90 kg	72 kg (7%)

The quality (as measured by citric solubility) of Superphosphate based fertilisers may differ between fertiliser companies, and from year to year. Farmers therefore, when ordering fertilisers, would be well advised to ask for the content of citric soluble phosphorous in the fertiliser. Farm consultants may also be able to provide this information.

If, say, a farmer knows that the farm requires a topdressing of 20 kilograms per hectare of "plant available" phosphorous, this would require 250 kg/ha of *good* quality Super, or 285 kg/ha of *poor* quality Super. On a 200 ha farm, this amounts to an additional 7 tonnes of Super required per year.

Note: see page D-6 for the calculations involved with this example.

The calculations are as follows -

- from the table on page D-5:

	Total P Content	*Cit. Sol.* P Content
Superphosphate	9 %	8 % (good)
		7 % (poor)

- the farm requires 20 kg/ha of "plant available" P
- therefore the calculations are:

  "Plant Available" P required (20 kg), divided by the Cit. Sol. percentage (8%), multiplied by 100:

  20 ÷ 8 x 100 = 250 kg/ha

  - or if *poor* super (cit. sol. of 7%) is used:

  20 ÷ 7 x 100 = 285 kg/ha

"Potassic Super" mixes are affected in the same way, as follows:

	Total P Content *(Note A. below)*	*Cit. Sol.* P Content
15% Potash Super	8 %	7 % (good)
		6.5 % (poor)
30% Potash Super	6 %	5.5 % (good)
		5.0 % (poor)
50% Potash Super	5 %	4.5 % (good)
		4.0 % (poor)

Note A: The total P content (%) is obtained from the advertised "N.P.K.S." rating of the fertiliser (refer to Fertiliser Company information leaflets, or Lincoln University's "Financial Budget Manual").

4.2 SULPHUR FERTILISERS

[Note: Refer also to Section 4.3.3; and to 4.1.1, under "Further Information on R.P.R. Fertilisers"]

4.2.1 Sulphur Content and Availability in "Sulphur Super" Mixtures

Tables 1 and 2 (below) show an analysis of a number of sulphur fertilisers, comparing sulphur content, form of sulphur, and availability of sulphur for plant use[5].

Table 1: Forms and contents of sulphur (and phosphorus) in Sulphur Superphosphate mixtures:

	% Sulphate Sulphur	% Elemental Sulphur	% Total Sulphur	% Phosphorus
Superphosphate	11	nil	11	9
Sulphur Super	10	9	19	8
Sulphur Super Extra	9	18	27	7
33% Sulphur Super	8	25	33	7
40% Sulphur Super	7	33	40	6
50% Sulphur Super	6	44	50	5

Table 2: Percentage of the Total Sulphur (see Table 1) which becomes plant-available in 1, 2 or 4 years:

	1 Year	2 Years	4 Years
Sulphur Super	90 %	96 %	99 %
Sulphur Super Extra	95	97	100
33% Sulphur Super	87	95	100
50% Sulphur Super	64	77	93
Screened Agricultural S	16-36	29-46	47-75

Note: These figures are for a cool temperate environment - most of South Island.

4.3 TIMING OF FERTILISER APPLICATIONS

(Excludes Nitrogen - See Section 4.6)

4.3.1 Timing of Phosphatic Fertilisers

Medium/High P Levels in Soil

Where P (phosphorous/phosphate) levels in the soil are medium to high, the time of application of phosphorous fertilisers is probably not crucial[6]. Phosphate is not leached from the soil, and so pasture plants have ready access to the soil reserves.

Low P Levels in Soil

Where phosphorous/phosphate levels in the soil are low, an application of a soluble P fertiliser (such as Superphosphate) is likely to boost pasture production about 2 to 3 months after application[6]. The greatest effect will be on clover growth, and therefore maximum benefit can be obtained by applying the fertiliser just before the period of maximum clover growth - summer/autumn[7].

4.3.2 Timing of Potassic Fertilisers

It appears that the effect of topdressing with potassium is short lived, and that potassium deficiency is usually most severe during times of maximum pasture growth[8]. Hence it is generally recommended that potassic fertilisers be applied in spring for greatest benefit, but that heavy applications should be split between spring and autumn. This is if more than 50 kg of potash per hectare per year is required (this equates to 330 kg/ha of 30% Potassic Super). Caution should be exercised on dairy farms where stock suffer from grass staggers (hypomagnesaemia) in the spring. Heavy rates of potassium fertiliser may exaggerate the problem, and so, topdressing should only be applied between the months of October and March[7].

4.3.3 Timing of Sulphur Fertilisers

In general, sulphur fertilisers should be applied in the spring to give maximum responses[7]. However, the ideal time for application, depends upon the type of sulphur and the speed at which the sulphate is leached out of the soil (depends on soil type and rainfall). M.A.F. recommendations* are based on the estimation of the "Sulphate Leaching Index" for the soil (see Tables 3,4 and 5 on page D-9). This index can be used to determine the best type of sulphur fertiliser to use, and the best time to apply it (see Table 6, page D-10). Note however that the most efficient fertiliser may not necessarily be the most cost effective product. It should also be noted that the indices and associated recommendations are approximate only.

**Information and tables have been taken from M.A.F. publication "Fertiliser Recommendations for Pastures and Crops in New Zealand" (1984) - see detailed reference[9] at end of Section Four.*

Table 3: Interpretation/Estimation of Sulphate Leaching Index, according to the amount of Sulphate Leaching in soils:

Amount of Leaching	Sulphate Leaching Index (S.L.I.)
No leaching	0,1,2
Slight winter leaching	3
Severe winter leaching	4
Complete winter leaching and some summer leaching	5
Complete winter leaching and severe summer leaching	6

(**Note:** On soils where much of the rainfall is lost by surface run-off, the sulphate leaching index will be **one less than shown in Tables 4 and 5 below.**)

Table 4: Sulphate Leaching Indices for SLOW DRAINING Soils:

	Phosphate Retention Figure (From Soil Test):		
	Less than 60%	60 - 85%	Over 85%
Annual Rainfall:			
Less than 500 mm (20")	2	1	0
500 to 750 mm (20" to 30")	3	2	1
750 to 1500 mm (30" to 60")	4	3	2
Greater than 1500 mm (60")	5	4	3
Irrigated Pasture:	4	3	2

Table 5: Sulphate Leaching Indices for FREE DRAINING Soils:

	Phosphate Retention Figure (From Soil Test):		
	Less than 60%	60 - 85%	Over 85%
Annual Rainfall:			
Less than 500 mm (20")	3	2	1
500 to 750 mm (20" to 30")	4	3	2
750 to 1500 mm (30" to 60")	5	4	3
Greater than 1500 mm (60")	6	5	4
Irrigated Pasture:	5	4	3

Table 6: Most Efficient Sulphur Fertiliser Type and Application Time:

Only sulphate sulphur (as in superphosphate or sulphate of ammonia) or elemental sulphur are considered. Elemental sulphur should have fine particle size (see page D-4 under "Further Information on R.P.R. and Longlife Fertilisers"), particularly in the South Island and the Central Plateau of the North Island.

Sulphate Leaching Index (from tables on page D-9)	Time of Topdressing : Early Spring *(Note A. below)*	Autumn
0, 1, 2	Any type, but sulphate preferable *(Note B below).*	Any type, but sulphate preferable.
3	Any type.	Any type.
4	Any type.	Any type - elemental sulphur preferable.
5	Elemental S; or split application of sulphate.	Elemental Sulphur *(see Note C below).*
6	Elemental Sulphur *(see Note C below.)*	Elemental Sulphur *(see Note C below).*

Note A: Early application (before the onset of spring growth) is essential, but if this is not possible, autumn application is recommended instead.

Note B: Elemental sulphur alone may be too slow acting in this situation particularly in developing pastures.

Note C: Where straight Superphosphate is used as a source of P, the sulphate content of this may be largely or completely leached from topsoils in these situations.

4.3.4 Timing of Fertiliser Mixtures:

With fertilisers containing a mixture of P, K, and S (also N - see Section 4.6), it may not be possible to select a single application time which is ideal for all of the components of the mix, so split applications (through the year) may be necessary[7].

4.4 FERTILISER FOR HAY and SILAGE PADDOCKS

(Adapted from Cornforth and Sinclair[9], 1984)

Additional fertilisers should be applied to replace nutrients removed in conserved pasture if the hay or silage is not fed back on the areas on which it was grown.

Additional requirements can be calculated as follows:

(Note: The figures below may need to be modified to account for the existing levels of these minerals in the soil.)

Phosphorus - 5 kg of "plant available" P (see Section 4.1.3) for every tonne of D.M. (dry matter - see Section 2.9.7)) of hay or silage made.

Potassium - 15 kg of potassium per tonne of *hay D.M.*
- 20 kg of potassium per tonne of *silage D.M.*

Sulphur - 3 kg of sulphur per tonne of hay or silage D.M.

Magnesium - for every tonne of hay or silage D.M:
If soil test (Mg) is above 14 - *no Mg fertiliser required*
If soil test (Mg) is 12 to 13 - *1.0 kg of Mg per hectare*
If soil test (Mg) is 9 to 11 - *2.0 kg of Mg per hectare*
If soil test (Mg) is below 9 - *2.5 kg of Mg per hectare*

Note: See also Section 4.6.1, page D-13, use of nitrogen fertilisers.

4.5 LIME

4.5.1 Pasture Growth Response to Lime (on mineral soils)

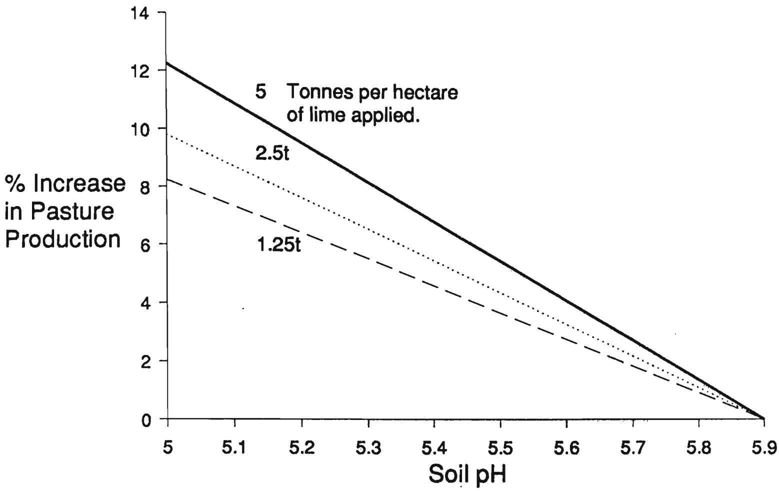
(Source: M.A.F.)

In general, if the soil pH is less than 5.8 (on mineral soils), applications of lime will increase pasture production. The lower the initial pH, the larger the production increase. For example (referring to Figure 1, page D-12), if the soil pH is 5.3, a lime application of 2.5 tonnes per hectare (1 ton/acre) should, on average, increase pasture production by just over 6% per year. However, if the soil pH is 5.7, the increase in pasture production would only be 2%, from the same rate of lime application.

Liming generally has its largest beneficial effects on pasture production through the summer and/or autumn.

Pastures are not reponsive to lime when the initial soil pH is in the range 5.8 to 6.0; and at pHs of greater than 6.0 liming may decrease production on some soils.

Figure 1: Increase in annual pasture production (on average) due to liming - at different soil pH levels.



4.5.2 Lime Required to Raise Soil pH

(Source: K.C.Cameron[7])

The change in soil pH produced by a lime application is influenced by the texture of the soil. Table 7 shows the amount of lime (tonnes/ha) required to raise the soil pH by 1 unit. For example, clay soils may only change half a pH unit with a heavy application of lime, say 6 tonnes/ha, whilst sandy soils are more responsive.

Table 7 : Lime Requirements

Soil Texture	Quantity of lime required to raise soil pH by 1 unit
Sand	2.5 tonnes per hectare
Sandy loam	4.2
Silt loam	5.6
Clay loam	8.3
Clay	12.5

In development situations it is desirable to reach the required pH as quickly as possible. After this there is usually no need to apply lime more frequently than every 4 to 5 years.

4.6 NITROGEN FERTILISERS

4.6.1 Nitrogen Fertiliser Usage on Pasture

(Adapted from Cornforth and Sinclair[9], 1984)

Fertiliser N (nitrogen) can be used to provide additional pasture during periods of shortage in late autumn and early spring. N should be applied 3 to 6 weeks before additional feed is required. However, careful grazing management is required to avoid the shading of clover plants by grasses - see "Pasture Management", below.

Approximate response rates, in terms of *kg dry matter* produced per *kg nitrogen* applied, are given in Table 8, page D-14. The response to nitrogen application can be variable, as is shown by the range of figures in brackets.

Pasture responses to nitrogen are generally greater and more reliable in spring than in autumn (refer also to "Further Information on Autumn/Winter Growth Responses", page D-15), although exceptions have been observed in Canterbury.

Pasture Management when using Nitrogen Fertiliser

Fertiliser nitrogen stimulates grass more than clover. It is better to sacrifice some of the potential growth response by grazing at an early stage (15 to 30 days after application) than to risk loss of clover balance by shading. Some loss of summer production has been observed following the use of nitrogen fertilisers in spring.

Adoption of the following guidelines will maximise benefits from fertiliser nitrogen:

(i) Select the nitrogen fertiliser that is cheapest per unit of N to apply. (see Sections 4.6.2 and 4.8).

(ii) Apply nitrogen to the pastures which are the most ryegrass dominant on the farm.

(iii) Apply only when climatic conditions are suitable for pasture growth.

(iv) In spring apply nitrogen to free draining soils first.

(v) There is no need to increase basal phosphorus, sulphur or potassium fertiliser applications when nitrogen fertiliser is applied, providing that normal maintenance has been applied and the levels of these nutrients are adequate to support normal pasture production. However, nitrogen is not a substitute for other fertilisers and the normal fertiliser policy for the farm should be continued.

(vi) Manage nitrogen-boosted pasture to favour the clover component during the spring-early summer period. Fit nitrogen applications into the normal farm rotation and avoid long intervals between grazings.

(vii) If a set amount of nitrogen is to be applied, it is better to apply 25 kg N/ha over an area than 50 kg/ha over half the area.

Table 8: The Response of Pasture Growth to Applications of Fertiliser Nitrogen.

The figures show the amount of ***extra pasture dry matter grown, per kg of nitrogen applied,*** *depending on the locality, season and rate of application. The figures in brackets indicate the variation possible.*

Region: *(See note below)*	**Spring** Rate of N applied: 25 kg/ha	50 kg/ha	100 kg/ha	**Autumn** Rate of N applied: 25 kg/ha	50 kg/ha	100 kg/ha
Warm temperate N.Island	9*(7-11)*	7*(4-9)*	4*(3-7)*	3*(3-5)*	3*(2-4)*	2*(2)*
Temperate N.Island	12*(8-16)*	10*(6-14)*	6*(4-8)*	8*(3-20)*	5*(2-14)*	3*(1-10)*
Remainder of N.Island, temperate S.Island	15*(12-24)*	13*(8-18)*	8*(7-11)*	8*(5-13)*	7*(4-9)*	5*(3-7)*
Cool-temperate S.Island	22*(12-27)*	20*(10-27)*	11*(10-13)*	11*(7-17)*	11*(6-17)*	5*(5)*

Note:

Warm temperate N.Island: *Northland, Auckland, S. Auckland, Waikato, coastal Bay of Plenty.*

Temperate N. Island: *Coastal areas, Taranaki, Manawatu, Hawkes Bay.*

Remainder of N. Island and temperate S. Island: *Central Volcanic plateau, King Country, Wairarapa Valley, coastal Marlborough, Nelson and Westland.*

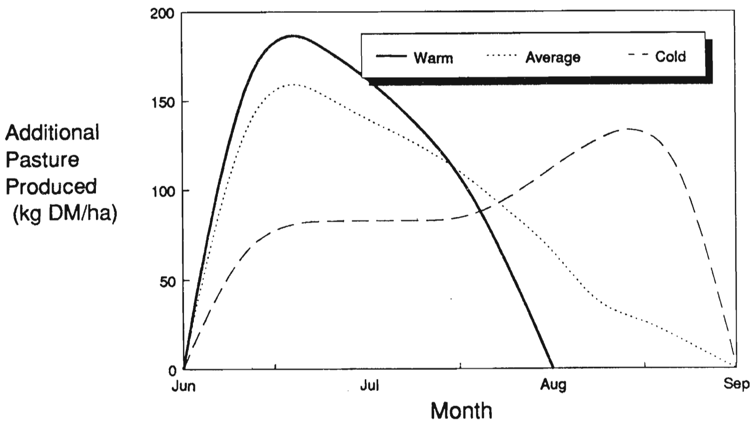
Cool-temperate S. Island: *Canterbury, Otago, and Southland.*

Further Information on Autumn/Winter Growth Responses:

Autumn: Pasture responses to N applied in autumn depend on the weather conditions before application and are best after a wet summer. During dry summers, high soil temperatures and low soil moisture restricts grass growth and therefore N uptake. However, mineralisation continues and there is a build up in "plant available" N in the soil. Therefore, after a dry summer, there is usually only a small increase in growth when N fertiliser is used[10].

Winter: When soil temperatures (10cm depth) fall below 5°C, both mineralisation and grass growth are limited. Therefore responses from N applied in winter are only worthwhile in warmer North Island areas (see Regions on page D-14). Even so, losses (e.g. by leaching following rain) can be quite large[10].
Figure 2 (below) shows graphically how the growth response to N (in Hamilton) can differ depending on the temperatures during the winter/early spring period[11]. In this instance, even in a cold winter with a slower response pattern, the *total* response to N was similar to the warm and average seasons.

Figure 2: Pasture Responses to 25kg N/ha in Warm, Average and Cold Winter/Early Spring Periods (Hamilton). Nitrogen applied mid-June.



4.6.2 Types of Nitrogenous (N) Fertilisers

Comments on Commonly Used N fertilisers: (For Pastures)
(Refer to Table 9, below, for chemical analysis)

Urea
The most commonly used nitrogen fertiliser in N.Z. Highly concentrated source of nitrogen, very soluble, but prone to N loss to the atmosphere through volatilisation when spread in warm dry conditions. Careful spreading important (evenly applied).

Sulphate of Ammonia/Ammonium Sulphate
An excellent source of both nitrogen and sulphate, in very soluble form. The most suitable N fertiliser for blending with other fertilisers as there is no problem with compatibility and has reasonable storage ability.

Liquid Nitrogen - Urea dissolved in water.

D.A.P. (Diammonium Phosphate)
A source of both nitrogen and phosphate in very soluble form.

N.P.K.S. fertilisers
Used in large quantities overseas and to an increasing extent in N.Z., these fertilisers come in a variety of formulations, providing four major nutrients (nitrogen, phosphorus, potassium and sulphur) in the one mix.

Nitrogen Super/Ammoniated Superphosphate
A good source of nitrogen, phosphate and sulphur, sometimes used to boost young pasture at the critical early establishment stage.

Table 9. Nutrient Content of Nitrogenous Fertilisers[9]:

	Percentage Composition (by weight):			
	Nitrogen	*Phosphorus*	*Potassium (K)*	*Sulphur*
Ammoniated Superphosphate	6 %	6 %	-	15 %
Ammonium Sulphate	21	-	-	24
Blood and Bone	5-8*	5-8	-	-
Calcium Ammonium Nitrate	21-28	-	-	-
Calnitro	21-26	-	-	-
Diammonium Phosphate (gran.)	18	20	-	2-3
"Liquid Nitrogen" (Urea Sol.)	20	-	-	-
Monoammonium Phosphate (gran.)	11	21	-	2-3
Potassium Nitrate	14	-	39	-
Sulphate of Ammonia	(see Ammonium Sulphate, above)			
Urea	46	-	-	-

* *Insoluble in water*

Calculating Topdressing Rates of Nitrogenous Fertilisers:

Table 10. Topdressing Rates to Supply Similar Levels of Nitrogen (N)[4].

Kg of N Required Per Ha:	Urea (46% N)	Liquid Nitrogen (20%N)	Sulphate of Ammonia (21% N)	D.A.P. (18% N)	N.P.K.S. mix e.g.'C.M.20' (20% N)
15 kg N	35 kg/ha	65 l/ha	70 kg/ha	85 kg/ha	75 kg/ha
25	55 kg/ha	110 l/ha	120 kg/ha	140 kg/ha	125 kg/ha
50	110 kg/ha	225 l/ha	240 kg/ha	280 kg/ha	250 kg/ha

(Note: refer to Section 6 for metric/imperial conversions.)

Liquid Nitrogen Volumes:
(See also Table 10, above).
1 tonne = 890 litres = about 200 gallons
1 gallon per acre = 11 litres/hectare = 2.5 kg N/ha (about)

4.7.1 Soil Testing the Farm
(Adapted from Cornforth and Sinclair[9], 1984)

(1) **Parts of Farm to be sampled:**
- Divide the farm into areas which have similar soil types, land use and topography.
- Collect separate samples for the major variations in soil type, topography, fertiliser history, management, stock or crop treatments.
  (*Editors note:* Ideally, collect at least two to four soil samples from each of the apparently uniform areas of the farm).
- Avoid small areas which are not typical.

(2) **Taking the sample:**
- One sample should consist of at least 15 soil cores (use correct equipment).
- Cores must be taken to a depth of 75mm in pasture and established lucerne and 150mm in arable land and land being prepared for lucerne establishment. Cores which break off shorter than the correct length must be discarded.
- Take cores at a regularly spaced grid throughout the area to be sampled.
- Do not sample near water troughs, gates, races, headlands, trees, dung or urine spots, abnormally wet or dry areas or areas with abnormal fertility.
- Do not sample immediately after pastures have been grazed.
- Do not sample within 3 months of applying fertiliser or lime. (pH could be affected by the lime particles for up to 6 months.)
- Sample well in advance of planned top-dressing dates.
- Resample every 3 to 5 years to monitor changes in fertility.
  (*Editors note:* Resample more frequently if topdressing policy is changing).
- Attempt to resample in the same season each year.

4.7.2 Interpretation of Soil Test Results (M.A.F.)

(Source: K.C.Cameron[7], adapted from Cornforth, 1981)

Soil test results (for pasture lands) are used to predict the likelihood of the pasture responding to applications of fertiliser nutrients, and so can assist in determining annual topdressing requirements.

Fertiliser Nutrient		Soil Test Level: Very Low	Low	Medium	High
Phosphate (P):					
Annual Rainfall:					
Over 1000 mm (40") Rain	Autumn Soil Test -	0-10	11-20	21-30	31+
	Spring Soil Test -			0-20	21+
Less than 1000 mm	Autumn Soil Test -			0-20	21+
	Spring Soil Test -			0-10	11+
Phosphate Retention(P.R.):			0-30	31-85	86+
Potassium (K):		0-4	5-6	7-8	9+
Sulphate (S):		0-4	5-10	11-15	16+
Magnesium[9] (Mg):			0-4	5-8	9+

pH (Lime) - see Section 4.5

4.8 COSTING OF FERTILISERS

(This section compiled by K. Cameron[7], 1986.)

Fertiliser composition is normally expressed as the percentage of each element N, P, K and S in the material (e.g. Sulphur Super 0.7.0.18 contains 0% nitrogen, 7% phosphorus, 0% potassium and 18% sulphur).

When deciding on which fertiliser to buy it is essential to cost out the available nutrient in each for comparison. The easiest way to do this is to calculate the cost of 1 kg of the nutrient in each of the alternatives using the formula:

$$\text{dollars per kg of nutrient} = \frac{\text{cost (\$) per tonne of fertiliser x10}}{\text{\% of nutrient}}$$

For example - see next page

Example:

Which nitrogen fertiliser gives the cheapest source of N: Urea, Calcium Ammonium Nitrate (CAN) or Ammonium Sulphate (Sulphate of Ammonia) ?

(A) **Urea**

N	P	K	S
46 %	0	0	0

Price (1990) $433.00 per tonne. Therefore the cost of N (using the formula above) is:

$$\frac{433 \times 10}{46} = \$0.94 \text{ per kg}$$

(B) **Calcium ammonium nitrate (CAN)**

N	P	K	S
28 %	0	0	0

Price (1990) $600.00 per tonne. Therefore the cost of N is:

$$\frac{600 \times 10}{28} = \$2.14 \text{ per kg}$$

(C) **Ammonium sulphate**

N	P	K	S
21 %	0	0	24

Price (1990) $276.00 per tonne. Therefore the cost of N is:

$$\frac{276 \times 10}{21} = \$1.31 \text{ per kg}$$

NOTE: Ammonium sulphate contains 24% sulphur and this may be needed by the plant. Therefore, it deserves to be credited with some value where we know it is needed. One tonne of elemental sulphur (100% S) costs $432 or $0.43 per kg S. Thus the 240 kg S in 1 tonne of ammonium sulphate is worth:

240 x $0.43 = $103

Allowing for this, the cost of N in 1 tonne of ammonium sulphate is:

$276 - $103 = $173

and the cost per kg of N is:

$$\frac{173 \times 10}{21} = \$0.82 \text{ per kg}$$

On a purely cost basis, one would buy (A) or (C) depending on the sulphate requirement.

See next page for further factors to be considered:

There are, however, other important factors to be considered when deciding on which fertiliser material to buy, these are:

1. Nutrient availability. Fertilisers which readily dissolve release their nutrients for plant uptake almost immediately. However, this also means that the nutrients may be quickly lost by either leaching or reaction with soil minerals.
   Fertilisers which are slow to dissolve do not have an immediate effect, but can be considered as slow releasing stores of nutrient. For example, with sulphur fertilisers, elemental sulphur is slow to dissolve and therefore should not be used to correct an immediate deficiency of S, but should be used when a more sustained supply is required. On the other hand, sulphate sulphur (as in Superphosphate) should be used for an immediate response. "Sulphur Super" fertilisers contain both forms of sulphur and therefore act as both an immediate and longer term supply of S.

   Editors Note:
   When costing different sources of phosphorus, those fertilisers which are based on Superphosphate require special consideration. In these cases, it is the cost per kilogram of *"plant available" or "citric soluble" phosphorus* which must be calculated. This is because not all of the P in the fertiliser is able to be used by plants (see Section 4.1.3). One tonne of Superphosphate contains 90 kg of phosphorus, but of this, only 70 to 80 kg is citric soluble, making the cost of this about $2.80 per kg P (1990 price of super $208/tonne). Note this calculation does not take into account the value of the sulphur content in Super. The same principle applies to all Superphosphate-based fertilisers, eg. Potassic Super mixes.

2. Physical form of the fertiliser. Fertiliser materials which are slow to dissolve often need to be finely ground and this may cause difficulties in handling and spreading. For example, finely ground elemental sulphur is explosive.

4.9 TRACE AND MINOR ELEMENTS

4.9.1 Trace Element/Mineral Deficiencies

- In Pastures and Crops - see Section 2.11

- In Livestock - see Section 1.3.2

4.9.2 Trace and Minor Element Fertiliser Materials

Table 11, below, lists fertiliser materials which can be used to supply requirements of trace or minor elements.

Sections 1.3.2 and 2.11 give recommended application rates for a number of these elements.

Table 11: Trace and Minor Element Fertiliser Materials[9]

Element	Fertiliser Material	% Content of Element
Boron (B)	Borax	11 %
	Fertiliser borate - 46	14 %
	Fertiliser borate - 65	20 %
Cobalt (Co)	Cobalt sulphate	21 %
Copper (Cu)	Copper sulphate	25 %
Iron (Fe)	Ferrous sulphate	19 %
Magnesium (Mg)	Dolomite	11 %
	Epsom salts	10 %
	Kieserite	15 %
	Serpentine rock (*see below)	18-25 (av.20)
	Magnesium oxide (pure)	60 %
	Calcined magnesite (Australian causmag)	55 %
	Calcined magnesite (Chinese)	50 %
Manganese (Mn)	Manganese sulphate	24 %
Molybdenum (Mo)	Sodium molybdate	39 %
Selenium (Se)	Sodium selenate prill	1 %
Sodium (Na)	Common salt	39 %
Zinc (Zn)	Zinc sulphate	23 %

*Leesite/Dunite very similar. Serpentine rock must be very finely ground to be effective.

4.10 SOILS (FEATURES)

4.10.1 The Soils of New Zealand
(Contributed by Dr. K.C. Cameron, Soil Science Dept. 1986)

Zonal Soils
There are five principal zones in New Zealand and the soils associated with them are called ZONAL SOILS. These zonal soils are found on parent materials such as loess (wind blown deposits), greywacke etc. which are largely made up of silica, feldspar and mica.

Brown-Grey Earths occur in dry inland areas of the South Island. The soils are sandy with clayey subsoils, relatively fertile but droughty. Yellow-Grey earths are widespread from Southland to Hawkes Bay and are formed mainly on loess-covered downs and hills under a sub-humid climate. These soils are silty with a dense fragipan and sometimes with a claypan as well in the subsoil. They require small quantities of fertilisers and some need artificial drainage.

Yellow-Brown Earths are extensive from Southland to North Auckland and up to the snowline on the mountains. They are formed under humid climates where leaching removes the soluble products of weathering. These soils require significant quantities of fertilisers to maintain productivity. The are friable, free-draining, silty to loamy textured but clayey versions occur extensively in Northland.

Podzols are formed under forest vegetation under extremely high rainfall; they occur in super-humid regions such as Westland. These soils are acid, very strongly leached and have low fertility. They require large amounts of fertiliser and lime for productive use.

Gley podzols occur mainly on terraces in super-humid regions where soils have become waterlogged after podzolisation. The gley podzols of Westland are extensively leached and have very poor internal drainage. Fertiliser and careful management are required to maintain productivity of these soils.

Over 40% of New Zealand consists of steeplands where the zonal soils occur as part of a complex pattern which includes young soils and fresh slope deposits.

Intrazonal Soils
In some parts of the country the soils differ from zonal soils because of the unusual effects of some rocks such as volcanic ash, limestone, and sands on soil formation. These as well as those formed in wet low-lying situations are called INTRAZONAL SOILS.

Yellow-Brown Pumice (young) and *Yellow-Brown Loams* (older) are the most extensive of these soils which are formed on volcanic ash in the central North Island. They have loamy, friable, free-draining profiles and contain allophane clays which absorb large quantities of phosphate. Some are deficient in trace elements and low in potassium.

Brown Granular Loams and Clays are a complex group of soils formed on andesitic rocks and occur as small patches from Southland to Northland. Their fertility is highly variable but many are highly productive when nutrient deficiencies are corrected.

Rendzinas are dark fertile soils formed on limestone.

Yellow-Brown Sands are leached soils on coastal dunes.

Gley Soils are poorly drained soils of swamps grading into peats in the wettest places.

Azonal Soils

Azonal soils are young soils without well-developed subsoils, formed in recent floodplains, sand dunes, ash deposits etc.

Recent Soils occur on the younger surfaces of valleys and plains. They are usually fertile but physical properties, soil moisture and drainage are highly variable.

Regosols occur on fresh sand deposits.

Lithosols occur on coarse rock waste in the mountains.

4.10.2 Soil Physical Conditions and Crop Production

(Source: Dr. K.C. Cameron, Soil Science Dept. 1986)

Of the many factors influencing the final yield of the crop, the physical condition of the soil is often the most important.

Soil Structure is the term used to describe the size and shape of the units, or aggregates, found in the soil. These aggregates are formed from the sands and silts being bound together by clay, organic matter and other soil components. The nature of these aggregates and their arrangement control the rate of water infiltration and drainage, the amount of water stored in the profile, and ease of root growth. Good soil structure consists of well-developed porous aggregates which are arranged in a close pattern but are not compacted. Good soil structure is also stable and is not easily broken down under cultivation or raindrop impact.

Unstable soils have aggregates which are easily broken down and a number of problems are likely to occur such as surface capping, compaction and cloddiness, and slaking and puddling. All of which result in poor drainage and poor root growth.

Over-cultivating may also break down soil aggregates resulting in underconsolidation which allows rapid drying of the seedbed and wind erosion.

Some of our most productive arable soils have weak unstable, structure, which readily breaks down during short periods of waterlogging. The weak soil structure encourages overcompaction by machines when the soil is wet and efficient drainage control is essential if farmers are to avoid risks of damage to the soil and crop loss in wet years.

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SECTION 5

FARM IMPROVEMENTS, STRUCTURES AND VEHICLES

5.1 FARM FORESTRY

Acknowledgement: *Sections 5.1.1 to 5.1.12 (inclusive)* have been contributed by Mr Ross Jamieson, Ministry of Forestry, Christchurch.

5.1.1 Planning

Key points to consider in planning to establish a woodlot, and governing choice of species:

1. Extent and location of area.
2. Purpose of planting, e.g. timber, fencing material, erosion control, shelter, firewood.
3. Site factors, e.g. present vegetation cover, climate, soil, altitude, topography.
4. Access for extraction of forest produce.
5. Future market demand.
6. Source and quality of tree stocks.
7. Whether or not adequate silvicultural treatment can be given once stand is established.
8. Restrictions on forestry under district schemes.

5.1.2 Site Factors

Climate

Temperature and rainfall are the main constraints. *Pinus radiata* will grow throughout New Zealand, but is damaged by heavy snowfalls. Douglas fir, *Eucalyptus obliqua* and *Eucalyptus regnans* require at least 750 mm (30 inches) rainfall for reasonable growth. Eucalypts are susceptible to out-of-season frosts so in colder districts they are better grown on hill slopes. For inland South Island areas with a severe climate, Douglas fir, Larch, *Pinus nigra*, and *Pinus ponderosa* are more suitable. A warmer climate is required by *Eucalyptus nitens* and *Eucalyptus obliqua*. Most species are harmed by salt-laden winds, but *Pinus radiata*, *Cupressus macrocarpa*, and *Eucalyptus botryoides* are tolerant.

Altitude and Aspect

Radiata pine will grow well up to 900m in the central North Island, to 600m in Canterbury and 500m in Southland. Douglas fir and *Pinus nigra* will often do better on colder or more exposed sites.

Soils

Physical condition is more important than nutrient content. Poor drainage is the most important limiting factor. A hard pan may impair growth. Poplars will grow in a wet soil, but also require fertility. Pines, cypresses and cedars will tolerate dry soils. Eucalypts are more sensitive to variations in fertility than pines. Fertilisers are not generally needed for satisfactory tree growth, but may be required on some infertile soils particularly in Northland and Westland. Choose a species known to perform well on your soil types. Beware of Boron deficiency. Foliage sampling is recommended.

Vegetative Cover

This can influence species choice and subsequent management. If rapid regrowth of weeds will occur, a faster growing species can compete better, e.g. radiata pine compared to Douglas fir on a gorse-infested site. Herbicides can be applied at a light rate over radiata pine for releasing from gorse and broom, but not over Eucalypts. Control of gorse before planting is desirable, as a gorse-infested stand can be an expensive and unattractive proposition for tending.

Tree Growth Rates - A Comparison of New Zealand Sites/Districts.

The Site Index for a district gives a measure of the relative productivity of a site for growing trees. It is defined as the predominant height of radiata pine at age 20.

Site/District Description	Site Index (metres plus a factor of 2m)
High altitude stands in the more arid parts of Marlborough, South Canterbury, and Otago; poorer soils on Canterbury plains stands subject to strong winds and salt-spray along the ocean foreshore: stands on nutrient-deficient sites without fertilising.	20 or less
Canterbury plains and lower foothills; Marlborough Sounds; some of the better sites in inland Otago(?)	22
Southland (excluding inland Otago); Canterbury hill country; Kaingaroa plains above 500m(?); coastal sands in the Manawatu and Canterbury.	24
Central Marlborough; Nelson and foothills (fertiliser applied where appropriate); inland Manawatu; Wairarapa; South Auckland above 370m.	26
Auckland coastal sands (fertiliser applied where appropriate); North Auckland and Coromandel clays (fertiliser applied where appropriate); coastal sands in Bay of Plenty (Matakana). Medium sites on Banks Peninsula.	28
South Auckland sites below 370m; Hawkes Bay below 500m; Taranaki, Rotorua-Taupo area below 500m.	30
Northern boundary area of Kaingaroa Forest; Bay of Plenty coastal plains; Gisborne hill country below 500m. Good Banks Peninsula sites.	32

5.1.3 Characteristics of Tree Varieties

(See also "Factors Affecting Choice of Species" and "Rotation Length" at the end of this Table)

Species	Site Requirements	Natural Durability	Wood Characteristics	Uses	General
Pinus radiata Radiata pine	Will tolerate most sites except poorly drained or high altitude.	Non-durable	Easily treated. Moderate strength and density. Sawing, seasoning, machining, painting and staining properties very good.	Posts, poles. Buildings timber-framing, boards, laminated beams, plywood, veneers, furniture. Pulp and paper.	The primary general purpose timber in New Zealand
Pinus nigra Corsican pine	Will tolerate colder and wetter sites than radiata.	Non-durable	Similar to radiata. Suitable for round produce because of fine branches and regular form.	Mainly posts and poles. Little planted now except where conditions could be too severe for radiata.	Much shower growth than radiata. More susceptible to pine needle blight (not in Canterbury).
Pinus muricata (blue strain) Bishop pine	Similar to radiata, but more resistant to snow because of stiffer branching habit, and shows similar growth at higher altitudes.	Non-durable	Similar to radiata.	Similar to radiata.	An alternative to radiata in heavy snow areas.
Douglas fir (see also next page)	Prefers a moist, cool site, requires 750mm annual rainfall, evenly distributed, for good growth. More intolerant of wet ground then pines. Does not stand coastal conditions.	Can be used untreated in most low-hazard situations i.e. protected from the weather.	Difficult to treat. Cannot be treated by ordinary pressure treatment. Strong. Does not machine or take paint well.	Framing and construction timber, particularly where high strength is required, so long as knots are small.	A valuable timber because of high strength and the fact that it can be used untreated for many purposes, i.e. because most of the wood is heartwood and this is immune to attack by common house borer.

Species	Site Requirements	Natural Durability	Wood Characteristics	Uses	General
Douglas Fir (cont.)	Is damaged by exposure to high winds. Not suitable for northern NI. Will stand snow well but can be badly damaged by out-of-season frosts so is better with good air drainage.				
Cupressus macrocarpa	Will tolerate a wide range of sites but requires a reasonably fertile, moist (but not wet) site for good growth. Tolerates coastal conditions.	Heart moderately durable.	Treatment as for Douglas fir. Good strength, density. Good sawing, seasoning, machining and painting properties, stable. High proportion of heart. Low impact resistance.	Framing, flooring, weatherboards, joinery turnery, boat-building. Furniture. General purpose farm timber.	A valuable general purpose timber. Very variable in form so requires careful selection of seed source. New selections are now available.
C. lusitanica Mexican cypress	Warmer sites, away from the sea. Moderately fertile and well drained. Requires rainfall greater than 750mm for good growth.	Similar to macrocarpa.	Similar to macrocarpa.	All-round building timber. Joinery and turnery.	Similar to macrocarpa, for warm climates.

Species	Site Requirements	Natural Durability	Wood Characteristics	Uses	General
Eucalyptus species:					
(A) Ash Group *E. delegatensis* Alpine ash	Cool climate, 1000m rainfall. Will grow in warmer, drier climates but prone to later failure. One of the hardiest eucalypts.	Non-durable. Difficult to treat.	Light, strong, pale coloured. Prone to warping, and to collapse when drying. Growth stresses are particularly severe in logs less than 40cm in diameter. Difficulties can be overcome by quarter-sawing of large logs, and by steam reconditioning.	Veneers, decorative panelling, furniture, turnery, joinery. Short-fibred pulp.	Suitable for inland areas where climate too severe for *E. regnans*.
E. regnans Mountain ash	Cool, moist climate with good cold air drainage, 750mm rainfall.	Non-durable. Difficult to treat.	*E. delegatensis* also prone to internal cracks which limit its use.		The most desirable ash-type eucalypt.
E. obliqua Messmate stringbark	Similar to *E. regnans* but slightly less frost-hardy and will tolerate somewhat drier sites and tight clay soils.	Heartwood moderately durable.	As for other ash eucalypts but darker in colour. Because of higher density is somewhat less prone to collapse.		An alternative where rainfall a little low or soil unsuitable for *E. regnans*.
(B) Gum Group *E. saligna* Sydney blue gum	Warmer NI and northern SI districts, 750mm rainfall.	Moderate durability	Tough, strong, hard-wearing. Reddish-brown. Sawing and seasoning difficulties as for ash group.	General building and farm use including fencing. Also veneers, furniture, panelling.	The best eucalypt for warmer climates.
E. nitens Shining gum	Will tolerate rainfall down to 600mm but for maximum growth 800mm+ is required. Prefers strong clay soils not light sandy types.	Non-durable. Difficult to treat.	The lightest coloured eucalypt. Some collapse problems - quarter sawing and steaming will remove most checks. Will stain and finish very well.	Veneers, high quality furniture and joinery. Excellent short-fibred pulp.	Very rapid growth on good sites. Insect attack now controlled with parasite. Will make a good shelter tree.

Species	Site Requirements	Natural Durability	Wood Characteristics	Uses	General
E. botryoides Southern mahogany	Similar to *E. saligna.* Will tolerate wetter soils and coastal conditions.	Durable.	As for *E. saligna.*	As for *E. saligna.*	Growth and form to E. saligna.

Factors affecting choice of species :

1 Site factors;
2 Land preparation needs;
3 Availability of tree stocks and relative costs;
4 Management requirements;
5 Market demand or other end-use;
6 Rotation lengths;
7 Aesthetic value.

Rotation Length

Pinus radiata	25-35 years
Pinus muricata	25-35 years
Pinus nigra	40-50 years
Douglas fir	40-50 years
Macrocarpa	30-50 years
Eucalypts	30-40 years

5.1.4 <u>Land Preparation</u>

Inadequate site preparation can lead to poor stocking, need for blanking (replacement planting), costly release clearing, unthrifty trees, and reduced management options.

Techniques for Establishment in Pasture :
Graze close prior to planting. Grass control is desirable, especially in fertile improved pastures where grass can compete strongly with tree for moisture. Use the recommended herbicide. Spot or line spraying is a popular and effective technique. Some sprays can be applied over pines after planting. Deep rip all compacted soils.

Gorse and Broom : Gorse sites are among the most expensive and difficult to prepare. Burning followed by planting is often unsuccessful as gorse regrowth beats trees, and access for tending is difficult. It is preferable to control gorse before planting. A combination of burning, roller crushing, cultivation, heavy stocking and/or one or more spray applications may be required. Preparation may take up to two years.

Scrub : For small scrub, crush and burn or bulldozing or cutting lines is suitable. For taller scrub, bulldoze clear, crush or fell and burn. Line cutting in scrub is highly desirable for some species.

Compacted stony or clay soils : Ripped lines allow easier planting and better establishment. Cultivate to 65cm minimum.

Frosty areas : Bare ground (sprayed or cultivated) lessens the effect of heavy or out-of-season frosts.

Cutover sites : Windrowed and/or burnt is preferable although it is possible to plant directly into cutovers.

5.1.5 <u>Planting</u>

Tree Stocks
The ideal seedling is short and fat - about 200mm shoot length and 100-200mm root.

Refer to table over page for seedling requirements (for North Canterbury conditions).

Recommended Sizes for Bare Rooted Seedlings for North Canterbury Conditions

Age (years)	Species	Minimum stem diameter (mm)	Desirable height (cm)
1	*P. radiata*	6	25-35
2	*P. nigra*	8	20
2	Douglas fir (oregon)	10	40-50
1	macrocarpa	6	25-35
1	Leylands	6	25-40
1	Eucalypts	8	50
1	*Acacia melanoxylon*	10	60-70

Care of Tree Stocks

Most trees are now dispatched in plastic bags - these should be stored one layer deep in a cool shady spot, with roots downwards so that condensation runs down. Bags should not be left in the sun to heat up.

If seedlings are not in bags they should be heeled in, in over-lapping rows until required for planting.

Planting Technique

A grubber is sometimes used in stony soil but is not generally recommended. A spade is highly desirable because of the large hole it makes, allowing good spread of roots, and should be used wherever possible. Roots should be well spread and directed downwards. Achieved by pulling the seedling upwards 3 to 5cm before firming the soil. The tree should be upright and deeper into the ground than it was in the nursery. Soil should be firmed around the tree so that no air pockets are left. Cutting away a patch of turf to provide a bare planting spot ('screefing') is recommended in grass, unless spot spraying is to be done.

Spacing

Will depend on: species, competing vegetation, degree of land preparation, prospects for sale of thinnings, possibility of grazing within the stand, etc. Generally close spacing is preferable.

Spacing is normally varied by varying the spacing between rows, with spacing in the line kept at 2 m (2 paces).

Common spacings are:

- Radiata pine: 2.5 x 2 m up to 5 x 2 m, most commonly 4 x 2 m (1250 stems/ha);
- other pines : 2 x 2 m up to 3 x 2 m;
- Douglas fir : 2.5 x 2 m or 3 x 2 m;
- Eucalyptus : 3 x 3 m for even crown development;

Cypressess : 2 x 2 m up to 3 x 2 m.
Agroforestry: 7 x 7 m up to 10 x 10 m

Close spacing results in earlier canopy closure, suppression of weeds or grass, smaller branches, restriction of diameter growth (unless thinning is done early), better form and more choice for selection of crop trees and higher planting cost.

Wide spacing results in later canopy closure and later suppression of weeds or grass, larger branches (hence more expensive pruning), less restriction of diameter growth, rougher form, less choice for selection of final crop trees, more scope for grazing within stand and lower planting cost.

Blanking (replacement of dead seedlings)
This is normally done the year following planting. If mortality (assessed the autumn following planting) is uniformly distributed and less than about 15%, blanking is not required. If over 15%, or concentrated in patches, blanking is necessary. Trees planted later to fill in gaps rarely form part of the final crop.

Fertiliser
Fertiliser application is not normally required for conifers, and can be disadvantageous by boosting top growth of pines and making young trees more likely to topple. May be necessary on phosphate-deficient or low-fertility soils in some districts. Can give a worthwhile boost to growth if applied after thinning.

Eucalypts will benefit from application of nitrogenous fertiliser (urea, blood and bone, diammonium phosphate) in spade slit 15-20 cm from tree (not uphill), at time of planting. DAP is most suitable for Canterbury soils.

Trace element deficiency must be rectified e.g. Boron for Canterbury foothills and Nelson gravels.

5.1.6 Releasing/Weed Control

It may be necessary to cut back competing grass, weeds or scrub hardwoods from young trees. Bracken, gorse and broom are among the most troublesome weeds.

Common methods:
Physical - hand (curved slasher etc.)
- mechanical (rotary slasher inter-row)

Chemical - spot or strip ground spraying for grass
- blanket aerial or ground spraying for grass or weeds.

Pines and Douglas fir are tolerant to a number of grass sprays, and also to some herbicides at light rates.

For sensitive species such as eucalypts, or when in doubt, trees can be shielded with a cone or tube for spraying. Release spraying of conifers for grass control is standard practice.

5.1.7 Woodlot Management

Tending Regimes:

- **Boards and Veneers**
  Pruning is necessary to produce clear (knot-free) timber. Logs capable of producing clear timber, particularly decorative veneers, are likely to command a premium and the objective of the private grower should be to grow this type of wood where possible. Management should be to prune as early as possible to keep knotty core to a minimum and early thinning to take best advantage of pruning by rapid diameter growth.

- **Framing Timber**
  Strength and stiffness are essential. Douglas fir is the ideal timber, but radiata pine is satisfactory for most purposes. Knots are acceptable provided they are kept small. Management should be to keep trees closely spaced in early stages, to suppress branch growth, unless pruning is to be carried out. This will mean later thinning than in board regime with consequent longer time to reach utilisable size. A high and even initial stocking will also be necessary.

  Should only be considered as a management objective when tending for clear wood is precluded by difficulty of access, shortage of finance etc.

- **Smallwood (posts and poles)**
  Can be profitable outlet for thinnings or for clearfelling of small trees. Demand fluctuates. Thinning for production of smallwood is not usually worthwhile unless access is easy and there is a market available. It is generally better to thin to waste than to delay thinning and restrict growth of final crop trees in the hope of profit from sale of thinnings.

- **Pulpwood**
  As a primary management objective, pulp or chipwood is unlikely ever to be profitable to the small grower. It can a be useful outlet for thinnings or otherwise unsaleable wood from clearfelling, providing the cost of cutting and extraction is less than that of thinning to waste.

- **Agroforestry (Wide Spaced Planting and Grazing)**
  (See also Section 5.1.13)
  An opportunity for combined land use. Initial spacing 5 x 2 m, 10 x 2 m or wider. On time pruning will be essential if timber above box-grade is to be obtained. Thinning will be done earlier than usual to maintain a grass sward as long as possible.

Sample Management Plans for Radiata Pine:

Good Site.
Final crop only (grazing possible).
Planting at 6.0 m x 2.0 m (830 stems/ha) Use improved genetic seedlings.

Height of Dominants (m)	Approx. age (years)	Prune height (m)	Stems/ha	Thin to leave stems/ha
5 - 6	5 - 7	0 - 2	400 (best 2 in 4)	400 (all pruned trees)
7 - 8	7 - 9	2 - 4	200 (best 2 in 4)	-
10 - 11	9 - 12	4 - 6	200	200 (all pruned trees)

Clear fell when the trees reach an average diameter at breast height over bark (d.b.h.o.b.) of about 60 cm.

Average Site.
Intermediate yields.
Planting at 3.0 x x 2.0 m (1700 stems/ha). Could be a weed infected site

Height of Dominants (m)	Approx. age (years)	Prune (m)	Thin to approx. stems/ha
5 - 6	5 - 7	0 - 2	Remove all stems that obviously will not yield a post - not less than 1000.
7 - 8	7 - 9	2 - 4	400 when average butt log will yield a 15 cm post (best 2 in 5).
10 - 11	9 - 12	4 - 6	200 when average d.b.h.o.b. of trees to be thinned is 33-35 cm (best 2 in 3). Will yield posts and small sawlogs.

Clear fell when final crop trees reach about 60 cm diameter at breast height outside bark.

Difficult Site.
Framing regime.
Planting at 2.5 m x 2 m (2000 stems/ha)

Height of Dominants (m)	Approx. age years	Thin to approx. stems/ha
15 - 18	12 - 15	400 (best 1 in 5)

In such situations, clear fell when required after the average stand diameter at breast height outside bark reaches 46 cm.

5.1.8 Pruning

The objective of pruning is to produce clear wood, generally on the first six metres of the stem, although it may be worth pruning higher on best sites.

Selection
Pruning should be restricted to those trees that will form the final crop plus a margin to allow changes in form and dominance, losses through windthrow etc. Points to look for when selecting trees for tending are:
- relative dominance and vigour
- condition of leader
- straightness of main stem
- erectness
- spacing in relation to other selected crop trees
- branch size.

Note: These criteria can change in relevance depending on the percentage of final element at first tending.
The trees to select for pruning are dominant and co-dominant.

5.1.9 Thinning

In the early stages of a woodlot, stocking will be fairly dense. The objective is to permit continued fast growth of selected trees by removing competition from unwanted, genuinely inferior, trees. Final crop stocking will depend on the desired product type. Get expert advice.

Technique - General
1. Aim to leave large, well-formed trees and remove small or badly formed trees.
2. Form is more important than spacing.
3. All hang-ups should be put on the ground.

4. Stumps should be kept low and felled trees completely severed from the stump.
5. All green branches should be cut off the stump.
6. Damage to crop trees should be avoided.

5.1.10 Protection

Fire

Fire risk is high after thinning, due to slash on the ground and dryer condition of the stand, and more intensive protective measures should be taken as this stage.

Fire breaks may be required around plantations depending on degree of risk. These should be up to 10 metres wide depending on the danger factor.

Animals

Opossums can be a problem in some conifers, poplars, willows and eucalypts, especially when the woodlots border on scrub or bush. Extensive damage can lead to death or malformation of young trees, to the extent that it may not be possible to select a final crop of good trees.

Hares and rabbits can also be problem causing damage by nipping off the leading shoots of young trees.
(See also Section 5.2.2 - Rabbit-Proofing Seedling Trees)

If control of these animals cannot be done by the owner, the local Authority may be able to assist. Contact your local Forest Research Station for advice.

5.1.11 Disease

Pine needle blight *(Dothistroma pini)* is fairly common in most of New Zealand, living on the tissue of the pine needles causing them to eventually die and drop off. Symptoms are brick-red bands on green needles, with small black spots. Spreads up from bottom of crown. Causes a decided decline in the tree's vigour and seriously hinders growth. Persists from year to year sometimes resulting in death. Ideal conditions which encourage the disease are a moist, mild climate and crowded stand. This is not a problem in Canterbury or Otago.
Dothistroma can be controlled by aerial spraying with copper-based spray. The Ministry of Forestry should be contacted for advice on methods.

Cyclaneusma minor causes yellowing of pine needles in spring and premature needle cast. The extent to which it reduces growth is not clear, but it is not regarded as a serious problem.

Phaeocryptopus (Swiss needle-cast fungus) affects Douglas Fir only. It is a widespread needle disease particularly apparent in the central North Island. It can be recognised by the sooty appearance on the underside of the needles and an abnormal needle cast.

Armillaria is a root rot causing mortality in both pines and Douglas Fir although the latter seems slightly less susceptible. The tree may eventually die. It is usually only a problem in land converted from native bush.

Eucalyptus Sawfly *Phylacteophoga froggatti*
Leaf mining by the larvae of this Australian wasp threatened the continued viability of Eucalyptus as a forestry species in New Zealand. Since its accidental introduction in 1985 the saw fly spread rapidly throughout the North Island. In 1988 a small Bracon wasp egg parasite was introduced to control the sawfly and to date has been a huge success.

5.1.12 Forestry/Woodlot References

Selling Produce From Your Plantation.
(New Zealand Forest Service. Information series no. 76.)

Radiata Pine - A Basis for Selection of Trees for Pruning & Thinning.
(New Zealand Forest Service. 4th Edition 1976.)

Establishing a Woodlot.
(New Zealand Forest Service. Information series no. 18.)

Management of Woodlots.
(New Zealand Forest Service. Information series no. 19.)

Utilisation of Woodlots.
(New Zealand Forest Service. Information series no. 20.)

Forestry Handbook 1977.
(New Zealand Institute of Foresters.)

5.1.13 Agroforestry: Stock Grazing under Trees

(Source: M.A.F.)
It is necessary to "feel the way" with early grazing, and a cautious approach with low initial livestock numbers is recommended. Dry ewes or lambs at 2 to 3 s.u./ha are considered satisfactory during this initial grazing period. Failures with early grazing are usually related to livestock numbers being too high. The manager must resist the temptation to utilise all available forage until the trees are above 1.2m.

Sheep are generally better suited to grazing in younger plantations because they cause less damage to the trees. Sheep generally find the bark too coarse in trees older than 4 to 5 years, although bark stripping has been observed in 5 to 6 year-old radiata pine. Cattle utilise forage growing in slash (thinning and pruning debris) much better than sheep, and also speed up slash decay. In older plantations, they also utilise the feed better than sheep. However, cattle can cause considerably more bark-stripping damage on trees up to 8 to 9 years old. With both sheep and cattle, stock regularly grazed under the trees cause less damage and are easier to handle than new stock brought in. Adult cattle and sheep are preferred to growing stock as their nutritive requirements are not so demanding.

There is evidence of abortion problems with cows grazing radiata pine foliage in late pregnancy. Until more information becomes available, it is recommended that breeding cows are kept out of forests for the last 2 months of pregnancy, or at least not given access to wilted foliage (pruning and thinning debris) during this period.

Bark stripping damage by both sheep and cattle generally occurs in late winter and early spring. Wet and cold climatic conditions are often associated with bark stripping.

Trees near gateways, troughs, stockcamps, or places where hay is repeatedly fed out suffer most. Larger plantations generally suffer less damage. Studies have shown that a few animals repeatedly cause most of the damage.

5.2 SHELTER TREES

5.2.1 Shelter Belts - Principles

(Source: MAF)

A good shelter belt requires adequate height, length and permeability:

Height: Wind reduction is directly proportional to the height of the shelter belt. A shelter belt deflects wind upwards, causing a reduction of windspeed on the leeward side. The original windspeed develops again at a distance from the belt of about 40 times the height.
Good wind shelter is provided to a lesser distance; about 20 times the height. This is the best figure to use in estimating the protected area.

Length: The length of the shelter belt is important in maintaining a reasonable degree of shelter when the wind veers from a direction at right angles to the belt. An increase in wind speed occurs round the ends of the shelter belt. Where the wind strikes the shelter belt at right angles, the length should be at least 24 times the height.

Permeability: A shelter belt should act as a wind filter, not as a solid barrier. Solid barriers divert wind and cause damaging turbulence. A permeability of 40 to 50% (ratio of gaps to solid) provides the smoothest airflow and maximum area of protection. The desired density can be obtained by selection of appropriate shelter species, adjustment of the spacing between trees and the number of rows of trees, and trimming and topping (silviculture).

Caution: Windbreaks established beside power or telephone lines should be at least 6 metres from the line on the downwind side. Tall trees should be kept at least 40 metres away from high voltage transmission lines. In all cases, the appropriate Authority should be consulted before planting.

5.2.2 Rabbit - Proofing Seedling Trees

The New Zealand Forest Research Institute has tried a variety of repellents and the following formulas are from those trials.

Egg Based:

80 g egg powder, 800 ml water (or five fresh eggs, 600 ml water), 150 ml acrylic resin (or 150 ml acrylic paint). Mix egg powder with some water to form a paste. Add remaining ingredients (or with fresh eggs, beat eggs well and add remaining ingredients). To apply, spray 20 ml per tree immediately after planting. May need to re-apply in the spring.

Mutton fat/kerosene:(good handling)

Ten parts mutton fat, one part kerosene. Melt fat and mix in kerosene. Allow to set. To apply, wipe tree with lightly greased rubber gloves. Dab ground at tree base or stake.

5.3 FENCING

5.3.1 Electric Fencing Guidelines (Gallagher Power Fence Systems)

(Information selected from Gallagher's 8th International Power Fence Manual)

Earthing or Grounding System:

A high powered energizer requires a large earth system. In areas with highly conductive moist soil all year round, three, two metre (6.5 ft) lengths of 25 mm (1 ") galvanised pipe driven into the ground, 3 metres (10 ft) apart should suffice. Dry soils have a very high resistance so, if possible, choose an area which is damp all the year, for example along the damp side of a building. To overcome the problem of high resistance in soils of low mineral content and ones which dry out severely, a Bentonite and salt system must be used. Salt is highly conductive and also attracts and holds moisture. Trials have shown a ten-fold improvement by using this system:

Bentonite and Salt System

Dig or drill holes at least 7 cm (3 ") in diameter, at least 10 metres (33 ft) apart, to at least 1.2 metres (4ft) in depth. Fill each hole with a wet slurry of 4 kg (8.8 lb) of Bentonite and 2 kg (4.4 lb) of coarse salt. Push a 1.2 m (4 ft) length of 10 to 15 mm (0.4 to 0.6 ") diameter stainless steel rod down the centre of the hole.

Stainless steel is used because salt is corrosive. Clamp the energizer earth wire to the tops of the rods.

In dry areas, spreading a few centimetres of coarse sand over the area reduces evaporation from the soil. In damp areas, the exposed salt will attract the moisture.

In drought conditions it may be necessary to water the earthing system.

Ensure that it is at least 10 metres (33 ft) from any power supply earth peg, underground telephone or power cable, or underground water pipe.

Note 1: Electroplated items soon rust and then create resistance so should not be used.

Note 2: Where the wire from the energizer to earth stakes is likely to come in contact with soil, yards, waterpipes or buildings, or if there is a milking shed anywhere near, use *Double insulated lead out cable.*

Testing the Earth:

If the earth system is inadequate a voltage reading will show, or if the earth system is touched, a shock will be felt. This is because the pulse current will be trying travel from the soil through the voltmeter or through your body to the energizer. In this case, the earth system should be improved.

Energizer earth systems should be tested at least once a year during the height of the dry period.

Before testing the earth system, short out the fence with several steel stakes placed between the live fence wires, and the ground, at least 100 metres (328 ft) from the energizer. Use a sufficient number of stakes to lower the fence line voltage to less than 1 kV. This will put the earth system under load.

Earth Return Wire System:
This system overcomes the problem of dry non-conductive soils not allowing sufficient current to flow back to the energizer through the soil to give a sufficient shock. By touching both live and earth wires on the fence the animal receives the full shock.
The energizer live and earth terminals must be connected to the fence live and earth terminals. The fences should have alternating live and earth wires and the earth wire should be connected to earth pegs, placed preferably in low damp areas or in Bentonite salt cores about every kilometre (0.6 miles) along the fence. These secondary earth stakes also help give protection against lightning damaging the energizer and they assist in eliminating shocks on gates, through the current taking an alternative route.

Wire Joints:
When joining wires in the middle of a fence, use a figure eight or reef knot.

Wire:

- 2.5 mm high tensile wire is recommended for electric fencing.

- Aluminium coated wire is best used for long lead-outs (several kilometres) because it is so much more conductive.

- Double insulated undergate cable should be used in buildings, under gateways, and where soil could corrode exposed galvanised wire.

- For long lead-outs, or for long distances underground, use double insulated lead-out cable (2.5mm).

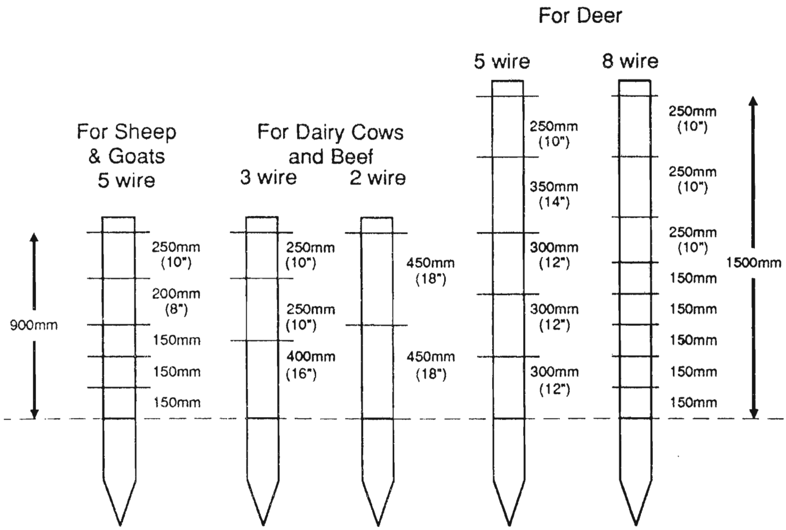
- For going under gateways, double insulated undergate cable or lead-out cable should be used for both the live and earth return wires. They should always be laid in a plastic pipe for physical protection.

Tensioning The Wires:
Adequate tension for 2.5mm (12.5 gauge) high tensile wire, is 90 kg (200 lbs).

"Insultimber" for Subdivisional and Boundary Fencing:
Suggested material quantities per kilometre (50 chains approximately):

Flat Land	- 25 "Insultimber" permanent posts
	- 75 droppers
Undulating Land	- 50 "Insultimber" permanent posts
	- 100 Droppers
	- 10 Tie Downs

"Insultimber" fence wire spacings for each animal type:



Insulators:
Porcelain insulators are the best because they last longer.

Plastic insulators must have a long tracking distance, and at least 1 cm (0.4") of material between the live wire and supporting post or rail. Tubing insulators are not recommended because the wire inside the tube corrodes when moisture, dust and insect acids collect. Shorts in tubing are very difficult to trace.

Rejuvenating Existing Non-electrified Fences:
Old fences which have deteriorated to the extent that they need complete replacement, can be rejuvenated to last for many more years by attaching offset brackets and an electrified wire on one or both sides of the old fence.
New fences will last almost twice as long if they have electrified offset wires attached to them.

All single offset wires should be attached at two thirds the height of the animals to be controlled. Where there are sheep and cattle to be controlled, either two wires may be used or a single offset may be attached at about three quarters the height of sheep and this will still control cattle and maintain the fence adequately.

Electrifying Remote Areas:

- A battery energizer can be used and the battery recharged every 2 to 6 weeks depending on its type and the amount of use.

- Existing electrified wires already going down the farm as a fence can be extended, or offset brackets and wires can be fitted to an existing conventional fence. In both cases if the distance is greater than a kilometre (0.6 miles), two or more electrified wires of at least 2.5 mm (0.1 ") gauge coupled in parallel every kilometre (0.6 miles) should be used to ensure adequate power at the end of the line. Good joins and joint clamps should be used. Double insulated undergate cable should be used under gateways or lead-out cable.

- An overhead transmission wire may be erected.

- A single 2.7mm (0.1 ") aluminium coated wire can be used as a lead-out wire for several kilometres (miles) because it is about five times more conductive than conventional steel wire.

- If the distance is greater than 2 km (1.2 miles) it may be more economical to use a solar powered energizer. These require minimal servicing so can be positioned in the centre of the area to be fenced.

Training Stock To Electric Fencing:

Select a small well fenced, holding paddock and place offset wires on this at about two thirds the height of the animals to be trained. Earth the remainder of the fence to the energizer earth and electrify the offset wires with the strongest possible pulse.

Training time:

The minimum time required is 12 hours and most animals will be fully trained in 48 hours. The aim is to have stock approaching the fences with caution.

Safety Requirements And Regulations:

All mains operated energizers must conform with the local standard requirements.

* No more than one energizer may electrify any one fence line at any one time.
* The energizer earth stakes must be at least 10 metres (33 ft) away from any other electrical earth peg or system to reduce the possibility of mains power flowing continuously through any electric fence.
* Where possible, avoid any fence line passing under or running parallel to power lines. If unavoidable the crossing should be made underneath the power

line and at right-angles to it. Where they are in the vicinity of overhead power lines, no fence wires should be higher than 2 metres (6'6") above the ground.

* The Post and Telegraph Act prohibits electrical interference to Telecom lines and the onus is on the land owner to prevent any audible interference. Where possible, avoid running any electrified wires under the telephone wires or parallel to underground telephone cables for any distance.
* It is also recommended to keep electrified wires well away from radio aerials.
* Local Body approval and advice regarding local regulations should be sought before constructing electric fences near roadways, stock routes, railways etc.

Warning Signs
Electric fences bordering public thoroughfares are required to have a warning sign at least 200mm x 100mm (8 x 4 ") in size every 90 metres (295 ft). The signs should display the words 'ELECTRIC FENCE' or the appropriate warning symbol. Any lettering should be at least 25 mm (1") high.

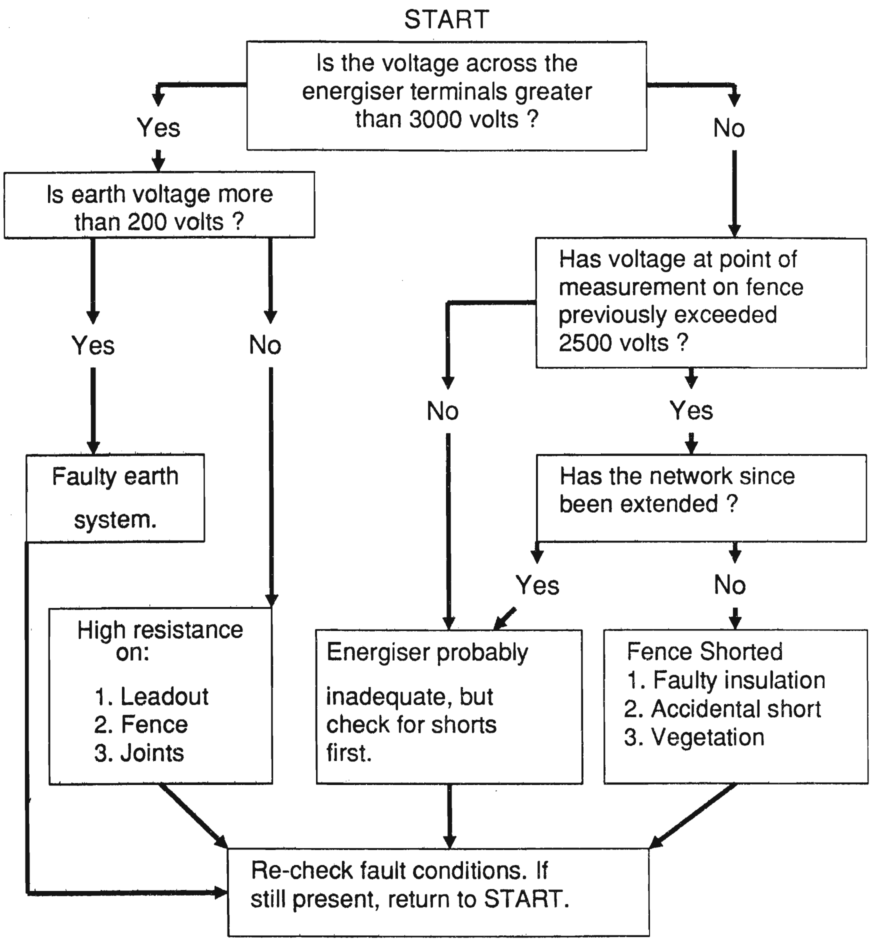
Fault Finding:
A digital volt meter is imperative for finding shorts. To trace a fault, isolate sections and travel along the fence line, testing at 100 metre (328 ft) intervals. If the short is serious, the voltage will drop and will continue to fall until the fault is reached. Once the fault is passed, the voltage will remain fairly constant and the operator must then back track a little way to find it. A fault finding chart is included in Figure 1 page E-25 .

5.3.2 Electric Fencing for Goats

(Source: Farm Equipment News March 1988)
This section gives only a summary of recommendations - detailed electric fencing information may be found in Section 5.3.1 (above).
Goats are naturally well insulated, with their long dry hair, dry skin and long bone hooves.

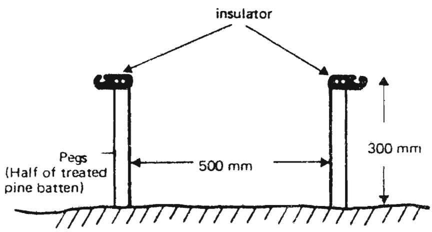
* Use a high powered energizer of about 10 joules or more.
* Design and build the fences correctly, with good insulation and conductivity to get full power to the back of the farm.
* Install electrified offsets or live wires on every fence.
* Have a well electrified training paddock and allow time and space to train animals.
* Install a good earth system.
* Keep at least 3000 volts on all fences.

Figure 1: Electric Fence Fault Finding Chart

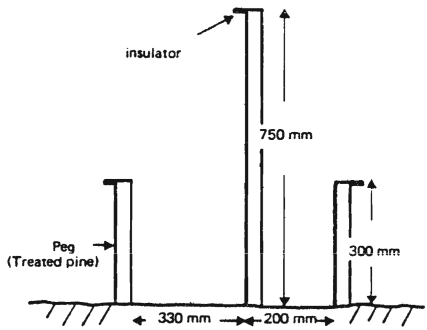


5.3.3 Electric "Grass Fence" Design
(Source M.A.F.)

(A) Two Wire Grassfence
Description: Two electrified wires on 0.5 m treated pine pegs about 14 m apart.



(B) Three Wire Grassfence
Description: Three 2.5 mm HT wires on treated pine pegs 0.5 m and 1 m in size, spaced at 14 m intervals.



5.3.4 Estimating Total Length of Fencing on Farms

Table 1 below provides a simple means of estimating the total length of fencing (existing or soon to be developed) on a farm, taking into account farm area and the number of paddocks.

Table 1: Metres of fencing required (per ha) for a given number of paddocks

	Size of farm:		
No of paddocks	1000 ha	350 ha	60 ha
8	19 metres/ha	32 metres/ha	75 metres/ha
16	25 metres/ha	42 metres/ha	100 metres/ha
32	37 metres/ha	63 metres/ha	150 metres/ha
64	50 metres/ha	84 metres/ha	200 metres/ha
(J.D. Squire, M.A.F. 1985)			

See also Section 5.3.1 for estimation of materials required for electric fencing.

5.4 WATER SUPPLY

Adapted from information provided by the Natural Resources Engineering Department, 1986.

5.4.1 Water Requirement

Average Rates of Demand

Average consumption figures (Refer to Section 5.4.2) may be used as a basis for preliminary planning. They may also be used to calculate time patterns of demand for the design of minor storages, provided that these time patterns are computed for the appropriate critical storage period.

Peak Rates of Demand

Peak consumption figures (refer to Section 5.4.3) should be used for the design of pumps, distribution systems, and spray irrigation layouts. They should not be used for storage design, except in the case of trickle-inflow storages for irrigation use.

Quantity and Time Patterns

In storage design, the use of average consumption figures for estimating reservoir demand may lead to under-design, particularly if the critical storage period is more than one year and includes two summers. A quantity-and-time pattern of demand must therefore be calculated. This is particularly important in the design of major irrigation storages, for which a detailed monthly analysis of irrigation requirements over a critical storage period of known severity is essential.

5.4.2 Average Water Requirements for Farm Water Supply

Average Daily Stock Water Requirements

Investigations carried out in N.Z. and overseas have resulted in the publication of observed rates of water consumption by livestock. Because of the nature of the factors influencing stock water consumption, there exists quite a divergence of opinion on this matter. The following figures are put forward as a reasonable basis for design [1].

	Litres/head - day
Dairy cattle - in lactation	70
- dry	45
Beef cattle	45
Calves	25
Horses - working	55
- grazing	35
Breeding ewes	3
Sows	25
Pigs	11
Poultry - per 100 birds per day	30
Turkeys - per 100 birds per day	55

Average Daily Domestic Consumption

The following figures are suggested as reasonable:

Household use including septic system - 180 litres /person/day
Household use excluding septic system - 135 litres /person/day.

Average Daily Garden Consumption

(To be used for the design of pumping and reticulation equipment).

Lawns and gardens for the growing of flowers, fruit and vegetables are an essential part of every farm homestead and require much larger quantities of water than are used in the house.

The quantity of water likely to be used each day on the house garden can be obtained by relating the consumption to the evapotranspiration as given in the expression:

$$C = 8000 \times Et.$$

Where C = likely consumption in litres per day per hectare
Et = *daily* evapotranspiration for pasture mm for the month of January (on average). (For average Et figures see Section 7.)

[In deriving this relationship it was assumed that the quantity of water used on the average house garden would be only 80 per cent of the evapotranspiration for completely vegetated surfaces having a plentiful supply of water.]

In view of the quantity of water used on a house garden it is most essential that the area of the garden that is actually watered be carefully measured.

Average Consumption on General Farming Activities:

Dairy Shed:

Cooling, cleaning of equipment and washing down of bails and other areas - 70 litres per cow per day.

Piggery:

Washing down of pens - 1500 litres per day per 100 square metres of area to be cleaned.

Sheep Dip:

Spray Dip - 1.6 litres per sheep for sheep 2 weeks off shears.
- 2.5 litres per sheep for sheep 2 to 6 weeks off shears.
- 5 to 7 litres per sheep for sheep over 6 weeks off shears (capacity of sump 1000 to 2000 litres).

Plunge Dip - Because of the greater wastage the above figures should be increased by 25 to 50 per cent (capacity of average dip 5000 to 7500 litres).

Fire Fighting: 1200 litres per 10 square metres of buildings.

Long Term Demands in Domestic and Stock Supplies

If the supply comes from a dam there must be sufficient capacity to meet the stock and domestic requirements for the longest period between replenishment from surface runoff. For most of New Zealand it can be assumed that the dam will be replenished once a year.

The average daily consumption of water in the house is more or less constant throughout this period, as is to a certain extent, the consumption of water in general farming activities. Consumption of water by livestock will vary to some extent because of changes in climatic conditions and the ages of the animals. It is suggested, therefore, that the long term requirements for stock be determined on the basis that the daily consumption for the period between replenishments is 75 to 80 per cent of the average daily requirements in the case of sheep and 80 to 85 per cent in the case of other stock (see page E-28).

The quantity of water used on the house garden over any period extending beyond several months and in different localities varies between wide limits. A greatly exaggerated figure would be obtained for the long term demand if the estimated consumption for the period between replenishments is based solely on an average daily consumption.

It is considered therefore that the actual quantity of water needed to produce satisfactory growth of the garden during the growing period should be determined having regard to location and rainfall and this can be done by using the expression:

$$C = 10{,}000 \times (0.8 \times Et - 0.75 \times R)$$

where C = likely total consumption in litres per hectare for the growing season.

Et = likely total evapotranspiration* during the growing season (on average).

R = likely total rainfall* during the growing season (on average) for the locality.

(**Note:For average evapotranspiration and rainfall figures for various districts of New Zealand - see Section 7).*

Storage Provision of Tanks and Dams filled by Pumping or Gravity from a Source of Supply

For windmill operated pumps, three to five days storage provision is required.

For pumps operated by other forms of power, the storage to be provided in case of breakdown depends mainly on the interruption that the breakdown will cause to stock watering. If other water supplies are available and stock can be moved to these supplies without great inconvenience then no storage is necessary. On the other hand if no alternative supply exists, at least two days supply should be kept in storage. This storage should be isolated from the main supply because often the breakdown is not noticed until all storage in the system is used and the troughs are dry.

Pumping Rates for Filling Storages from Supply

To determine the pumping rate to replenish a storage tank or dam, consideration should be given to:

1. Type of pumping equipment to be used;
2. Nature of the supply, especially where withdrawal rates could approach low flows;
3. Accessibility of pumping equipment;
4. Possibility of using off-peak power at special rates.

The following points are listed for design purposes and as a general guide:

1. For trunk mains to storage reservoirs, tanks etc., by power driven pump, discharge rate to be based upon filling storage in approximately 12 hours. However, in the case of an electrically operated pump and a large storage tank there is no reason why a pumping period of 24 hours cannot be used.

2. For trunk mains to storage reservoirs, tanks etc. by windmill driven pump.

   Minimum discharge litre/hour = 10 to 12.5 percent of the total daily demand in litres depending upon make of mill.

5.4.3 <u>Peak Water Requirements for Farm Water Supply</u>

(Maximum Rates of Consumption for Domestic and Stock Purposes)

Household Supplies:

To calculate the maximum flow rate to a house it is first necessary to list all the outlet points in the house and then to make a rational estimation of how many of these points are likely to be used simultaneously during peak periods.

The discharges of various outlet points within a household are as follows:

Shower, bath, laundry	5 to 15 litres/minute
Toilet cistern	5 to 7 litres/minute
Kitchen sink	10 to 12 litres/minute

For example in a household of two adults and two children it would be reasonable to assume that in the early evening the bath, kitchen sink and toilet cistern could be in use simultaneously, hence the total flow could be:

Bath	14 litres/minute
Toilet	7 litres/minute
Kitchen Sink	11 litres/minute
	32 litres/minute

Stock Supplies:
The lack of definite information on stock drinking habits makes any estimate of peak rate of demand to stock supply points open to argument.
It is suggested that peak demands be determined on the basis that the average daily consumption is used on a period 3 to 4 hours in case of set stocking in large area paddocks and 10 to 12 hours for intensive stocking on small sub-division paddocks.

General Farm Supplies:
Suggested values for the maximum rates at which water will be used in general farming activities are outlined below:

Dairy	- cup washing	10 litres/min
	- washing down (high pressure)	90 to 100 litres/min
Piggery		14 litres/min/outlet
Fire fighting		100 to 150 litres/min at a head of 25 to 35 m.

Garden Supplies:
The maximum rate at which water is used on a house garden depends mainly upon the size of the garden. Most house gardens today are watered by garden sprinkler. A typical garden sprinkler on a 13 mm garden hose has a flow rate of approximately 15 litres/minute. For a very large garden it may be necessary to operate two sprinklers simultaneously, hence the required flow rate would then be 30 litres/minute.

5.4.4 Working Lives for Farm Water Supply Equipment

Structures	
Wells and bores	25 years
Windmill	20 years
Pumphouse or shed	20 years
Pumps	
Deep-well turbine pump:	
Bowl	16,000 hours or 8 years
Column etc.	32,000 hours or 16 years
Centrifugal pump	30,000 hours or 15 years
Low lift, high discharge, axial flow pump	30,000 hours or 15 years
Motors	
Electric motor	50,000 hours or 25 years
Diesel engine 900 rpm or more	28,000 hours or 14 years
Less than 600 rpm	30,000 hours or 15 years
Petrol engine air cooled	8,000 hours or 4 years
water cooled (1200 rpm +)	28,000 hours or 14 years
water cooled (less than 1200 rpm)	40,000 hours or 20 years
Miscellaneous	
Asbestos-cement pipeline	20 years
Aluminium sprinkler line	15 years
Galvanised sprinkler line	15 years
Sprinkler head	8 years
Earth irrigation ditches	15 years
Concrete irrigation ditches	20 years

5.5 IRRIGATION

5.5.1 Units of Measurement used in Irrigation

(See also Section 6)

The unit for depth of irrigation is the millimetre. 1 mm (depth) = 1 litre/m^2 = 10 m^3/ha. The hourly rate of application and infiltration should be in millimetres per hour (1 mm/h = 1 litre/m^2/h).

5.5.2 Irrigation Scheduling

(Contributed by D.R.Wilson, D.S.I.R. Crop Research, Lincoln.)

It is important to schedule irrigation effectively to maximise yields and use water efficiently. Under-watering causes yield loss through water stress, and over-watering may cause problems such as water-logging or, in light soils, fertiliser leaching.
The best approach is to schedule irrigations on the basis of crop or pasture need. This can be done by monitoring ***soil moisture deficits (SMD)*** by either maintaining a water budget or measuring them directly with a neutron probe. The results can then be used to decide:

- When a paddock should be irrigated.
- How much water should be applied each time.

When to Irrigate

To avoid yield reductions caused by water stress, irrigation should start when the SMD reaches the point where half the "plant available" soil moisture has gone from the rootzone. The time it takes to reach this point depends on how much water has been lost by ***evapotranspiration (Et)*** and how much has been gained by rainfall and irrigation since the soil was last at ***field capacity****; the difference between these gains and losses is called the water balance, and can be followed in a water budget.
The amount of Et depends mainly on sunshine and temperature, and usually varies little from district to district within a region. Et figures are published daily in a number of regional newspapers and farmers can use them along with local rainfall figures to calculate estimates of their SMDs (- see also Section 7 for average monthly Et and rainfall figures).
Alternatively SMDs can be measured directly with a neutron probe. This must be done regularly during the season in each paddock.
Commercial irrigation scheduling services are available in some regions. As well as measuring SMDs with neutron probes, the consultants provide practical irrigation scheduling advice.

* *Field Capacity: Maximum amount of water that the soil can hold.*

Soil Water Availability

Soils vary greatly in their *total* water holding capacities. For example, at field capacity heavy clay soils may hold over 35% of water by volume while sandy soils may only hold about 20%. However, there is much less variation in the amount of water which is effectively "plant available". Most soils hold somewhere between 150 and 230 mm per metre of depth (see Tables 1 and 2).

Table 1: *Plant Available* Water-Holding Capacities (Average) of Soils of Various Textural Classes

	Soil Depth:	
	Top 0.3 metres (12 ")	**Below 0.3 metres**
	Plant Available Water: (mm per metre depth)	
Soil Texture		
Sand	150*	50
Loamy Sand	180	110
Sandy Loam	230	150
Fine Sandy Loam	220	150
Silt Loam	220	150
Clay Loam	180	110
Clay	175	110
Peat	200 to 250	At least 200 to 250

* *Example: The mm of available water in the top 0.3 metres of a sandy soil is -*
0.3 x 150 = 45 mm

***Note 1**:- Before Table 1 is applied to the soils of a farm, a number of earth auger test holes should be made to determine variations in the depth and textural class of the soil within the effective crop root depth.*
***Note 2**:- Where detailed determinations of the water-holding capacities of soils have been made, those values should be used in place of Table 1.*

Average values of available water holding capacities for several New Zealand soil groups are shown in Table 2.

Table 2: : *Plant Available* Water-Holding Capacities (Average) of Soil Groups in New Zealand

	Soil Depth:	
	Top to 0.3 m	**Below 0.3 m**
Soil Group:	*Plant Available water: (mm per metre depth)*	
Northern Yellow Brown Earths	175	110
North Podzols and Podzolized Soils	220	90
Brown Loams on Basalt	130	75
Brown Granular Clays (North Auckland)	175	150
Brown Granular Loams (South Auckland)	160	75
Yellow Brown Loams	200	120
Yellow Brown Pumice Soils	260	220
Central & Southern Yellow Brown Earths	200	110

Yellow Grey Earths	220	110
Brown Grey Earths	180	-
Organic Soils (Peat)	200 to 250	At least 200 to 250

The *soil depth* is more important than these figures. In a shallow soil the depth usually limits the amount of available water. On the other hand, if a soil is deeper than the roots penetrate, not all the so called "available" water is accessible to the plants. Thus, it is important to know the soil depth to which various plants root (see below).

Crop Rooting Depths

Plant rooting depths are very variable, depending on many soil, environmental and management factors, but typical rooting depths for a range of crops are given in Table 3. If rooting is restricted, by a pan for example, then rooting depths will be less. This can only be determined by digging a hole and having a look.

Table 3 : Typical Effective Crop Root Depth Under Irrigation

Cash Crops	Root Depth Metres	Pasture and Forage Crops	Root Depth Metres
Barley	1.0	Choumoellier	0.5
Beans	0.5	Fodder beet	0.5
Maize	1.0	Lucerne	1.6
Oats	1.0	Millet (fodder)	0.5
Potatoes	0.7	Pasture - annual	0.6
Peas	0.7	- perennial	0.7
Sorghum	1.0	Rape	0.5
Tomatoes	0.9	Turnips	0.4
Wheat - autumn	1.5		
- spring	1.0		

How Much Water to Apply

Enough water should be applied to reduce the SMD to between zero and half the water holding capacity (plant available) of the soil.

It is not advisable to return the soil to field capacity (i.e. to reduce the SMD to zero) because the advantage of any rainfall will be lost. The SMD should be made sufficiently small to ensure that enough water is available to meet the crop requirements until the next irrigation. The quantity of water required will be about the same as the amount of evapotranspiration (Et) which has taken place in the preceding period.

Summary

* Determine/Calculate the amount of water holding capacity (plant available) for each soil and crop combination. It is necessary to know the soil type, soil depth and the probable crop rooting depth.
* Monitor the SMD by either maintaining a water budget or measuring it directly with a neutron probe.

* Irrigate when the SMD reaches the point where half of the "plant available" water has gone from the root zone.
* Apply enough water to reduce the SMD to close to zero.

Further Information:
M.A.F. Aglink FPP 89, 1984 Irrigation Management: Water budgeting for surface irrigation.
M.A.F. Aglink FPP 274, 1984. Irrigation Management: Water budgeting for spray irrigation.

5.5.3 Efficiency of Application of Irrigation Water

For sprinkler irrigation systems, efficiencies within the range 80 to 90 per cent can be achieved with good equipment correctly used (see Table 4 below).

Table 4: Efficiency of Application* for Various Irrigation Methods

Method of Application	Application Efficiency (%)
Spray:	
Night watering	90
Average day watering	80
Day watering in hot, windy weather	60
Control flooding:	
Border check	75
Border ditch (dyke)	70
Contour check	75
Semi-controlled flooding:	
Contour ditch	60
Keyline system	65
Wild flooding, little or no land preparation and no spreader banks	50

* *Efficiency of Application: An efficiency of 90% means that 90% of the water applied reaches the rootzone and becomes "plant available".*

Application Rate
Application rate should be varied according to the infiltration rate of the soil, the average slope of the irrigated area, the amount of plant cover, the soil surface characteristics and the total volume to be applied (see Table 5, over page).

Table 5: Estimated Maximum Water Application Rates

Soil Groups Based on Texture and Profile	Slopes* 0-8° mm per hr	Slopes** 9°-12.5° mm per hr	Slopes*** over 12.5° mm per hr
Sands and light sandy loams uniform in texture.	31.8	25.4	20.3
Sandy loams overlaying a heavier subsoil	20.3	16.5	12.7
Medium loams to sandy clays over a heavier subsoil	16.5	12.7	10.2
Clay loams over a clay subsoil	12.7	10.2	7.6
Silt loams and silt clays	10.2	7.6	5.1
Clays	6.4	5.1	3.8
Peat	16.5	-	-

* 0-8° - level to undulating

** 9°-12.5° slope - undulating to low hills

*** over 12.5° slope - low to steep hills.

Note 1: The above figures are intended for guidance only.

Note 2: For bare soil such as undertree watering of orchards and watering of vegetables, the above rates shall be reduced by up to 50 percent (to avoid soil loss or damage to structure).

Note 3: Lighter application rates should be used when pastures and crops are being established.

For flood irrigation, the amount applied per watering, rather than application rate, will determine the area which can be watered in the irrigation cycle from a given water supply or with a given size of pumping plant. This is because infiltration rates are relatively high in the initial stages of application, but as watering continues, a more or less steady, much lower, rate of infiltration occurs. Thus for a particular soil, it may take 1 hour to apply 25 mm but 3 or 4 hours to apply 50 mm.

5.5.4 Irrigation Comparison

There are now many kinds of sprinkler irrigation systems available; their labour and pressure requirements vary greatly as do their capital costs. In the following check-list, labour requirements generally decrease, while capital costs increase:

Handshift (cheapest and highest labour)

End-tow

Travelling gun

Side-roll (and travelling side-roll)

Travelling, rotating boom

Travelling linear boom

Centre pivot (most expensive and lowest labour)

Detailed technical information is generally available from manufacturers and suppliers. Some data for travelling irrigators is included below.

		Big Gun	Omme	Roto-Rainer	Turbo-Rainer	Fixed Boom LHW
Range of crops		All	All	All	All	All
Output litre/sec		10 - 44	11 - 23	7 - 42	up to 40	up to 40
Sprinkler Pressure	(KPa)	400 - 600	300-400	200 - 280	70	280
	(PSI)	60 - 90	45-60	30 - 40	10	40
Area/400m run ha		2.5 - 4	up to 3	1.2 - 4	2.8 - 3.6	4
Run width (metre)		60 - 100	75	60 - 100	70 - 90	100
Gross appln mm		33 - 90	40 - 65	up to 90	5 - 95	30 - 90
Labour per shift		1/2 hour	1/2 hour	1/2 - 1 hour	1 hour	1/2 - 1 hour
Tractor required		yes	yes	yes	yes	yes
Boom operation		-	fixed	rotating	fixed	fixed
Ground wheels travel on		wet or dry	dry	wet	dry	-

For other factors affecting choice of irrigator - see over page.

Other Factors:
Big Gun - Easily affected by wind. High Pressure
Omme - No winch. Follows hose around curves. 3 speeds.
Roto-Rainer - Big droplet size. Travel geared to rotating boom. Good for pasture.
Turbo-Rainer - Ultra low pressure. Requires smaller main line. Least wind affected.
Fixed Boom LHW - Piston driven. Even speed travel.

5.5.5 Trickle Irrigation

Trickle irrigation is a simple, efficient method of delivering water to plants. Horticultural crops and shelter belts are most suited to trickle irrigation.

Advantages:

1. Low cost of installation, maintenance and materials;
2. Low labour input in operation functioning;
3. Efficient use of water, provided management is correct. Able to maintain a high degree of control on water application. Water stress should not be experienced;
4. Generally lower pressures are required, and a smaller water source may be used;

Disadvantages:

1. Filtration may be difficult in some areas;
2. Over-watering may occur unless system is carefully monitored.

Almost any water source is suitable for trickle irrigation as the system works on lower flow rates than conventional. The pressure frequently required may vary from 1 to 40 m head (10 to 400 kPa) although 6 to 12 m head (60 to 120 kPa) is recommended.
Blockages occur easily in small microtubes and suitable filters should be incorporated. Microtube and drippers have small holes to control water flow which tend to block up. When pumping from a dam site the pump intake should be kept well clear of the bottom, yet fairly deep to avoid weed and algae.
Minimum filtration would be in a line strainer of B.S.100 mesh (150 microns); for algae B.S.50 mesh (300 microns).

Sub-main or header pipes are usually 38-50 mm commercial grade, low density, polythene pipes; but smaller dimensions are suitable in some circumstances. P.V.C. header pipes may also be used. Laterals - thin walled polythene pipes 10, 13 or 16 mm in diameter. They are normally laid out on top of the ground so 'whiskers' can be easily checked.
Commonly used microtubes or whiskers sizes are 0.5 and 0.9 mm.

Watering Rate

The actual rate varies according to climate and the physical properties of the soil and the property layout. For berryfruits and small shrubs 1 litre/hour is often adequate and for larger trees and shrubs 4.5 litres/hour.

Water Distribution

Trickle irrigation in New Zealand is supplementary to natural rainfall, therefore, distribution to the rooting zone is not as important. However, as much of the rooting area as possible should be watered and the number of whiskers used depends on plant size and soil type.

Daily Water Requirements

Total daily water intake depends on plant size and the level of evapotranspiration. Approximately 3.5 litres per square metre of foliage per day is the peak water requirement during December, January and February. For example, a tree covering an area of 14 square metres will require 49 litres/day as a peak requirement. These figures are an approximate guide.

5.6 STRUCTURES and STORAGE

5.6.1 Sheep Yards

In this section, some facts, figures and hints on the design and building of sheep yards are presented.

There are several points to consider when planning the building of a new set of yards:

- Decide the location of the yards according to access, drainage, shelter, and supply of electricity and water. The yards should be situated in a central position as much as possible to avoid driving the sheep long distances. There should be some shade in the yards if they are not covered. Trees should not be planted alongside races as the sheep tend to stop in the shady patches. Water should be available to the sheep in the holding pens, especially if they are to be held overnight due to the mob size preventing a job being completed in one day.

- Decide where the holding pens should be and their size.

- Carefully plan the handling area, bearing in mind that sheep move more willingly up a slope and that shadows should not be cast ahead of them.

- Decide the features of the handling race(s) - type of floor, raised or at ground level, length and method of adjusting the width.

- Lay out the forcing, holding and receiving pens - possibly incorporating existing yards or woolshed.

- Draw up the plan to scale.

- Construct the yards in temporary form, using posts, hurdles and netting to test whether the design will work satisfactorily in your particular circumstances.

Yard Size

The first consideration is the number of sheep and the number of separate mobs most likely to be yarded at the same time. An average of 0.5 square metres of yard space should be allowed for each sheep. This gives ample space for working any but the largest sheep. For overnight holding in yards sheep require 1.0 square metres per animal.

Covered Yards (see also Section 5.6.5)

There are three main points to consider when incorporating covered yards:

- Under normal conditions space should be provided to house about one third of the flock.

- The crush pens, drafting race, and general handling facilities should be located on the warm open side. Generally the South or cold side is closed in, but lit with translucent sheets. This allows sheep to remain away from rain drift and easily provides both outside and inside drafting.

- Drafting: 3 ways is common, but in some plans sheep can be directed about 10 ways with a 3-way draft under cover. By using exit gates, large mobs can be drafted. Generally the yard floor is left as is. Some success has been achieved with wood chips, sawdust or small gravel.

For further reading see References 2 and 3, Section 5.8

5.6.2 Cattle Yards[4]

The main purpose for which cattle yards will be used will influence their design and construction. For example, on breeding properties, good facilities are required for calf handling - drafting, marking, dehorning, inoculating, drenching, and spraying. Where A.I. is used, there must be suitable provision for the veterinarian to inseminate the cows in safety.
Where the farm enterprise is mainly buying stores and fattening, then drafting, holding and loading facilities are most important.

Designing the Yards
Most of the points mentioned in relation to sheep yards in Section 5.6.1 are applicable to cattle yards as well. It is very important to plan the facilities carefully as the cost of a set of cattle yards is considerable. Estimate holding capacity with regard to expected future needs. The yards can be made larger from the outset (depending on the financial situation) with the elimination of some of the internal structures that are not needed immediately.

The yards do not necessarily have to handle every animal on the property at the same time. Capacity will vary according to the property enterprise and scale of operation. Calculate yard size by allowing about 2.5 square metres of yard space for each animal in the receiving yard. The forcing yard should be designed to hold about one third of the number accommodated in the holding yard. The basic components of a cattleyard are much the same as for sheepyards. Crush length should provide about 1.7 m for each adult animal, while 2 square metres per animal is sufficient in the drafting pens. These pens are used infrequently and only for a relatively small number of cattle. For large groups of cattle, design the yard so that larger pens can be used in conjunction with the drafting pens if necessary.

Cattle, like sheep, have no colour vision so every item is seen in terms of black, white and grey. Contrasts in dark and bright surfaces can cause cattle to baulk. Covered yards should be lit with fluorescent lights rather than incandescent bulbs.

Loading ramps should not face into the early morning or late afternoon sun as cattle find it difficult moving down such ramps.

The social order within a group of cattle works against a free movement of the animals at points of constriction in yards and races and the lead up to a crush should be a slow one with no abrupt angles.

A good cattle race limits the side vision of a cattle beast and directs it to the area ahead. This is of little use if the cow is required to walk into a blind alley. Cattle will stop 6 to 8 metres from a blind end. The gates ahead should be of the grill type so the stock can see straight ahead.

Any lead-in to a crush should have a curved approach, though if the angle of the curve is greater than 15 degrees, a straight portion, the length of a cow, should be built immediately before the crush.

Single file alleyways should be not longer than 7.5 metres without a curve or bend, though bends should not deflect at an angle greater than 15 degrees. Sharp turning corners of 30 degrees or greater, should be avoided.

Overhead walkways frighten cattle; catwalks should be on the side of the races at waist-height so handlers can reach over and contact cattle. At this height arms cannot be crushed and most of the time the operator is out of sight of the animal. Rubber rollers on the side or bottoms of gates, the areas which will come into contact with a beast if it decides to rush past, will allow the cow to push past without being bruised. This is especially important where the doors are compressed-air controlled.

New concrete floors should have a 10 mm deep grove 20 mm wide on a 100 mm grid pattern worked into them and older floors can have grooves cut into them about 600 mm apart when they are repaired. The positions of drains should not impede flow of cattle. If cattle have to unload downhill, steps are preferable to ramps which soon become slippery with dung and urine. Stair steps 80 mm in rise and 350 mm in run, work well for cattle.

The height of cattle yards is usually 2.4 m, although this can vary according to the conditions and personal preference.

For further reading see References in Section 5.8

5.6.3 Cattlestops

There are several designs for cattlestops that have proved useful over the years[5]. Two are described over the page.

The first design can be made with either railway irons or pipe rails; the latter is preferred by some farmers because they cause less injury to stock that get stuck in the cattlestop. The most common width is 3.6 m, with the length varying from 1.5 m (where it is needed to deter only the occasional wandering animal) to 2.5 m. The pipes (50 mm diameter) are welded to two steel bearers at least 150 mm deep and positioned under the wheel tracks. The gaps between the pipes can vary from 95 mm to 125 mm. The ends of the pipes are welded into the inside angle of lengths of 50 x 50 x 9 mm angle steel resting in small steps in the end wall of the concrete surround. There are short spacers of 12 mm pipe welded between the rails above the bearers to prevent the pipes from rolling under the immense force of a heavy, braking vehicle. Steel strips can be welded across the top of the rails but sheep often try to walk across them.

The concrete surrounding wall should be 100 mm thick provided it has plenty of steel reinforcement. There should be a tolerance of at least 40 mm between the steel frame and the concrete. The floor of the cattlestops is of concrete 50 mm thick and 370 mm below the level of the rails. If a cattle beast steps through the rails, it can stand on the bottom of the pit.

The need for intermediate concrete foundations under the bearers depends on the expected loadings and on the size of the bearers.

Another design, adaptable for either pipes or rails, involves steel strips welded across the pipes. Expansion links join them with bolts through oversized holes in fishplates. The rails rest directly on intermediate concrete bearers at wheeltrack positions. They are securely welded to steel strips at the ends but these are made of flat steel rather than angle iron. Where rails are used, short spacers are welded at their base as well as steel strips being welded on the top. Pipe of 50 to 76 mm diameter is suitable for this design.

The pit is 1.5 m across and all concrete walls are 200 mm thick. The pit is deeper than in the first design with a drainage hole two-thirds up the wall. This means that there is usually some water in the pit, adding to the visual barrier effect.

A slight modification to the standard design is to lay the rails at about 25 degrees instead of right-angles to the approaches. This means that a car 'ripples' rather than bumps across. The gap between the rails needs to be as wide as possible, with 50 mm pipe being used instead of railway irons.

5.6.4 Deer Yards

(Source : M.A.F.[6])

There is no such thing as a 'standard' deer yard. Most successful yards have some, or all, of the following points in common:

1. A long lead-in race, close-boarded for about 9 m out from the yards. Ideally, this should not be straight, but should offer an indirect approach so that the yards are hidden from the animal's view until the last few metres.

2. The working area, should have closely boarded walls which are at least 2.1 m high for Red deer, or 2.6 m for Fallow.

3. Sheet or corrugated iron should be avoided as it is noisy.

4. Plywood is well supported on framing to avoid 'drumming' on impact.

5. A central, circular crush pen with two centrally placed swing gates is common in many designs. Farmers often use them more for directing stock into lateral pens, rather than as a crush. Five metres is a suggested maximum diameter.

6. Small pens (the actual number depends on herd size) for working with small numbers at close quarters. Large uncovered areas can be used for holding large numbers.

7. A floor covering of sand, wood chips or coarse saw-dust.

8. Closed storage facilities for equipment.

9. Usually sheep-type drafting gates do not work, hand drafting is easier.

10. Long narrow raceways should be avoided.

11. Corners should be avoided if possible, especially in crush and drafting areas.

5.6.5 Woolsheds

(Source M.A.F.[7] - see also Section 5.8, References, for sources of information on other aspects of woolshed design and example plans).

Smaller wool sheds with covered yards have become popular. However, the covering of sheep is secondary to the main functions of a woolshed, which are quick and easy pen filling and good operational facilities for shearing, wool handling and classing. An older shed can be brought up to a higher standard by adding a raised board, and catching pens with a 1.8 m race behind. Additional gates to allow side filling is a great improvement as it cuts down sheep movement and shed hands' time. Poor light can be simply and cheaply corrected by placing a strip of corrugated translucent sheeting about 0.6 m wide down from the top plate along each side of the building.
A big advance in woolshed design in recent times is the concentration on filling catching pens from the front and side and the placement of all pens, so that they lead directly into the catching pens.
An allowance of 0.37 square metres should be made for holding sheep overnight, and comfortable space provided in covered yards (see also Section 5.6.1).
The chute shed design is still the most popular and efficient.
The curved or U-shaped boards are gaining popularity and give excellent wool handling facilities.
Correct shearing board measurements are of vital importance - see over page for details.

Regulations
(Source: M.A.F.)[5]
Certain requirements are necessary and some details are now mandatory, for satisfactory working conditions:

1. All catching pen doors must be padded at point of shearer contact.
2. Any new or altered shed must have one catching pen door per shearer.
3. Each woolshed must have a hand basin and water. If accommodation is not supplied - hot water must be.
4. Toilets provided within easy access.
5. A smoko compartment isolated from the board furnished with tables and chairs must be incorporated.
6. The shed must be in a clean state before shearing.
7. It is also mandatory to have all sheep skins removed from catching pen areas.
8. Counting sheep into catching pens is not allowed, counting out pens or recognised automatic counters must be used.
9. All machinery must be checked and in good working order.
10. A first-aid kit should be placed in a convenient position.

Raised Board - Measurements 1.7 m (5'6") wide x 0.76 m (2'6") high. Savings 35% of walking, compared with flat board.

Height Above Ground - Lorry height 1.1 m (3'9"). Many sheds now have concrete woolroom floors 0.3 m (12"), then raised board at 0.7 m (2'6") to give grating height of 1.0 m (3'6"). Bale loading is achieved by backing lorry into a position about 0.6 m (2') below concrete block 0.3 m (12") high if concrete woolroom is incorporated. Height about ground depends mainly on personal preference.

Stud Height - Minimum 2.6 m (8'6"), maximum 2.7 m (9'). With raised board woolroom 2.7 m (9') grating 2.0 m (6'6").

Lighting - Most important, if sheep are to run well. Corrugated plastic sheets placed in roof tend to give light spots so 0.6 m (2') strips should be placed down from top plate to provide light at important positions in the shed. Windows provide the rest.

Sarking - Black building paper is too dark. Silver sizalation is better, but timber sarking is best and strongest.

Ventilation - 0.9 m (3') 5 blade louvres are excellent if placed in a position to give maximum light and encouragement to draw sheep. Roof vents are good.

Gratings - Spacing 15 mm (5/8") bevelled on one side. Width depends on personal preference. Suggest 32 mm to 37 mm (1.25" to 1.5") x 32 mm (1.5") deep. Bevel to face away from oncoming sheep. Grating to be changed if necessary to suit progress of sheep.

Gates - Lift and swing type is the most popular, followed by lift, then tip or swing types.

Landing and Ramp - Woolroom loading block no bigger than 1.8 m x 0.9 m (6' x 3'). Sheep ramp-steps 300 x 150 mm (12" x 6") or 250 x 125 mm (10" x 5"), steps are very effective for sheep and man.

Pens and Partitions - Depends on breed of sheep. Height for Romneys or Corriedales 0.86 m (2'10"); up to 900 mm (3'0") maximum for, say, Perendales. Rub rails staggered to stop sheep seeing through. Catching pens should hold about 15 sheep.

Wool Rooms - Allow minimum of 5.2 m (17') between edge of raised board or board wall and outside wall for wool room. This gives room for wool table, bins etc. Allow approximately 1.3 m (48") x 0.76 m (2'6") for a bale of wool while a pack holder should measure 0.99 m (39") x 0.69 m (27"). This fits inside the pack.

Wool Tables - Rectangular measurements 2.6 m (8'6") x 1.3 m (4'3") x 0.84 m (2'9") high. Circular diameter should be 2.1 m (7'). Battens are suitable at 32 mm (1.25") x 32 mm (1.25").

Board Layout - Very important. If chute is used it must jut into the board 150 mm (6") and be attached to the bottom of the joist to give a drop of 100 mm (4"). This allows the front feet of the sheep to drop straight into the chute with no risk of returning. Chute to be at 45 degree angle for 1.1 m (3'6") then a walkoff at 25 degrees.

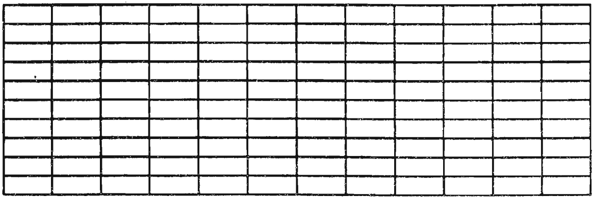
5.6.6 Haybarns

Capacities (Standard "small" bales):
Rectangular shaped barns such as lean-to or gable have a nominal capacity of 5 bales of hay per cubic metre.
Circular arch shaped barns are often available in 8.5 metre wide kitsets with "bay" lengths of 3 metres. Each "bay" has a nominal capacity of 500-550 bales of hay.

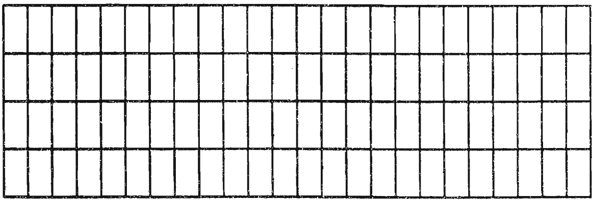
Stacking Hay
(Source: M.A.F.)
The basic principle of building stacks is to make sure that each bale crosses a bale in a lower layer to form a solid stack (see diagram page E-49).

With the bottom bales placed on their cut edges little wastage occurs. All other layers are laid with the cut edges to the outside where possible.

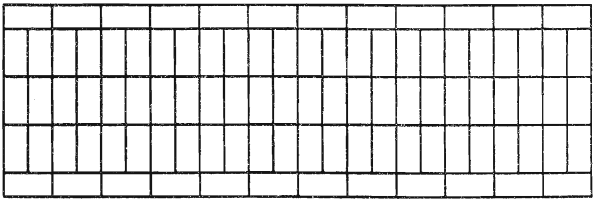
When building the layers (other than the base) build from the ends to the centre, and from the sides to the centre. Any gaps must be left in the centre.



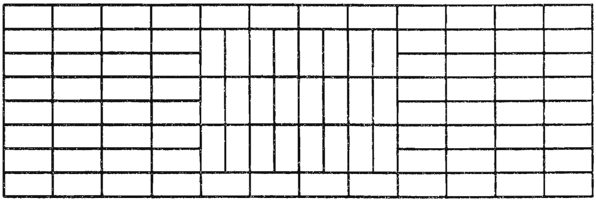
FIRST OR BASE LAYER
CUT EDGES DOWN



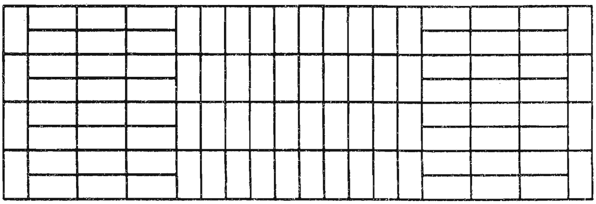
SECOND, FOURTH, EIGHTH
AND TENTH LAYERS



THIRD AND NINTH LAYERS



FIFTH AND SEVENTH
LAYERS



SIXTH LAYER

5.6.7 Grain Storage Buildings

Calculation of Silo Volume and Storage Capacity
For calculating volume and capacity of silos the following formulas can be used:

Volume of a cylinder:

$$\left(\pi r^2\right) h$$

Volume of a cone i.e. the base or top of a silo:

$$\left(\pi r^2\right) \frac{h}{3}$$

Where π = 3.142 (approximately)
r = the radius
h = height

The capacity can be calculated using the cubic metre weights of grain as follows:

Wheat/Peas	750 kg per cubic metre
Barley	624 kg per cubic metre
Oats	498 kg per cubic metre

Note: These cubic metre weights are approximate, based on 14 percent grain moisture content, and may vary slightly with cultivar.

For example, to calculate the tonnes of barley able to be held by a flat bottomed silo with a conical top, having the following dimensions:

3.7 metres in diameter (radius is therefore 1.85),
2.5 metres in height to the start of the conical roof (eave),
and 3.5 metres in overall height (including the eave).

Therefore the capacity of the silo in cubic metres is:

$(3.142 \times 1.85^2 \times 2.5) + (3.142 \times 1.85^2 \times 1.0 \div 3) = (26.88) + (3.58) = 30.46\text{m}^3$

If the weight of 1 cubic metre of barley is 624kg (see above):

30.46 x 624 = 19,007 kg = 19 tonnes.

See over page for capacities of various silos.

The table (below) provides volumes of some standard sized, galvanised steel silos (permanent, on concrete pad, with conical top).
Source: Dan Cosgrove Ltd.

Diameter (m)	Eave Height (m)	Overall Height	Tonnes Capacity*		
			Barley	Maize	Wheat/Peas
3.66	2.46	3.51	19	22	22
	4.90	5.95	36	40	42
4.58	3.27	4.59	39	44	46
	4.09	5.41	48	54	57
	4.90	6.22	57	63	67
5.49	4.09	5.67	71	79	83
	5.71	7.29	96	106	113
	7.34	8.92	121	134	142
6.41	4.09	5.93	99	110	116
	5.71	7.55	133	147	156
	7.34	9.18	167	185	196
7.32	4.09	6.20	131	145	154
	5.71	7.82	176	195	206
	7.34	9.45	221	244	260

* 44 bushels barley per tonne
39.4 bushels maize per tonne
36.7 bushels wheat or peas per tonne

Note that no allowance has been made for compaction, which can be up to 5%.

Steel Mesh Silos
Silos can be made from steel mesh lined with hessian scrim, and situated in an existing shed. The most common size is 15.5 m circumference, 4.5 m diameter, with height of 2.3 m. A silo of these dimensions has a capacity of about 37 cubic metres. The mesh is joined by "U" bolts and clips. These silos should ALWAYS be filled or emptied from the centre.

5.7 FARM VEHICLES

5.7.1 Fuel Consumption of Tractors

The following figures are a guide only.
Under normal cultivation conditions, it can be assumed that a tractor will use approximately **0.32 litres of fuel, per hour, for every** ***kW of power*** *. This figure is for new tractors. The fuel consumption also varies according to the load on the engine, the way the machine is used, age of the tractor, the size and type of implement attached, speed of travel and condition of the soil.

* *kW of power: The proper definition, is kW of maximum PTO power, which is the manufacturer's power rating for the model of tractor. Horsepower and kW conversions may be found in Section 6.11.1, page F-20.*

For example:
A 100 kW (134 hp) tractor operating at 75% of maximum power uses:

100 kW x 0.75 x 0.32 litres = 24 litres per hour.

Note 1: Fuel consumption would be higher for heavier duty work (e.g. ploughing) and less for light implements (e.g. harrowing and crop sowing).

*Note 2: The consumption is only during the actual working time of the tractor. If the field efficiency*** *of the tractor were to be only 60%, then actual fuel consumption would be reduced to 14.4 litres per hour (24 litres x 60%).*

** *Field Efficiency is the ratio of the effective work rate to the theoretical work rate. It takes into account the times when the equipment is out of work, for example turning on headlands, filling drills etc. See pages E-53 to E-55 for average field efficiency figures.*

5.7.2 Tractor Hours and Work Rates

Rate of Work*** (ha per hour) =

$$\frac{\text{operating speed (km/hour)} \times \text{implement width (m)} \times \text{field efficiency (\%)}}{1000}$$

*** *To calculate the time taken per hectare, take the reciprocal of the* ***rate of work*** *figure. For example, if the rate of work is 5 ha per hour, the time taken per hectare is 1 ÷ 5 = 0.2 hours = 12 minutes.*

Tables 1 to 3, on pages E-53 to E-55, give examples of typical work rates of farm equipment. *For further reading see References 8 and 9, page E-60.*

Table 1: Work Rates of Cultivation Equipment
See Section 6.11.1 for horsepower/kW conversions.

	Normal Working speed (km/hr)	Width (Metres) of Implement	Tractor power (kW)	Field * Efficiency (%)	Estimate of Working Rate ha/hour	hours/ha
Ploughing:						
3 furrow	4.8-5.5	0.9-1.1	34-45	80*	0.40-0.42	2.4-2.5
4 furrow	4.8-5.5	1.2-1.5	45-60	80*	0.54-0.58	1.7-1.9
5 furrow	5.0-6.0	1.5-1.8	55-65	80*	0.65-0.72	1.4-1.6
6 furrow	5.0-6.0	1.8-2.1	70-80	80*	0.81-0.85	1.1-1.2
Rotary Cultivator	4.0	1.5	34-45	85	0.51	2.0
	3.2	1.5	34-45	85	0.41	2.5
Heavy Tine	5.6	2.1	34-45	85	1.00	1.0
Cultivator	5.6	3.0	45-60	85	1.43	0.7
	5.6	3.7	over 60	85	1.76	0.6
Spring Tine						
Cultivator	8.9	2.7	23-34	85	2.04	0.5
/Harrow	8	4.0	34-45	85	2.72	0.4
	8	6.7	45-60	85	4.56	0.2
Light Harrow	6.4	3.0	23-34	85	1.63	0.6
Disc Harrow	5.6	2.4	34-45	85	1.14	0.9
	6.4	3.0	45-60	85	1.63	0.6
Heavy Disc Harrow	6.4	3.2	over 60	85	1.74	0.6
Roll	6.4	4.9	23-34	85	2.67	0.4
3 row ridger	4.8	2.1	23-34	80	0.81	1.2
Conventional	8	2.4	45-60	65	1.25	0.8
Drill	8	3.0	45-60	65	1.6	0.6

* *Field Efficiency of ploughing will be higher where reversible ploughs are used. (See page E-52 for definition of F.E.)*

Table 2: Work Rates of Mowing, Baling and Harvesting Equipment

See Section 6.11.1 for horsepower/kW conversions.

	Normal Working speed (km/hr)	Width (Metres) of Implement	Tractor power (kW)	Field * Efficiency (%)	Estimate of Working Rate ha/hour	hours/ha
Mowers						
Bar	5.6	1.5	23-34	75	0.63	1.6
Flail	6.4	1.5	34-45	85	0.81	1.2
Rotary	9.7	1.5	34-45	80	1.16	0.9
Hayrake	8.0	3.0	23-34	85	2.04	0.5
Tedder 1 row	8.0	1.5	34-45	85	1.02	1.0
2 row	8.0	3.0	34-45	85	2.04	0.5
3 row	8.0	4.6	34-45	85	3.13	0.3
Baling	6.4	3.0	45-60	50-60	1.0-2.3	1.0-0.4
Combine Harvester						
-medium capacity	3.2-6.4	3.0	-	75	0.72-1.44	0.7-1.4
-high capacity	3.2-6.4	3.7	-	75	0.89-1.78	0.6-1.1
-high capacity	3.2-6.4	4.3	-	75	1.03-2.06	0.5-1.0
-v. high capacity	3.2-6.4	6.1	-	75	1.46-2.92	0.3-0.7
Forage Harvester						
- Flail	4.8	4.8	-	65	0.37	2.7
- Full chop (pick up)	4.0	4.0	-	65	0.78	1.3
Potato Harvester						
- 2 row	2.4	2.4	-	70	0.30	3.3

* *Field Efficiency: See page E-52*

See over page for Table 3.

Table 3: Work Rates of Spraying and Fertiliser Spreading Equipment

	Application Rate/ha	Swath width (metres)	Field * Efficiency (%)	Normal Working Speed (km/hr)	Estimate of Working Rate ha/hour	Hours/ha
Crop sprayer	- 225 litres	4.6	50	6.4	1.47	0.7
	- 225 litres	12.2	40	6.4	3.12	0.3
Fertiliser Spinner	- 375 kg	6	50	8	2.40	0.4
	- 1250 kg	6	40	8	1.92	0.5
Bulk Handling	- 375 kg	6	75	8	3.60	0.3
	- 1250 kg	6	50	8	2.40	0.4

* *Field Efficiency: See page E-52*

5.7.3 Sprayer Calibration and Cleaning

Accurate application of a chemical is very dependent on correct use and calibration of spraying equipment.

Calibration of spray equipment:

*Note: Always consult the manufacturer's directions first***.

Some general guidelines are published here, and a number of useful formulas are included on page E-59.

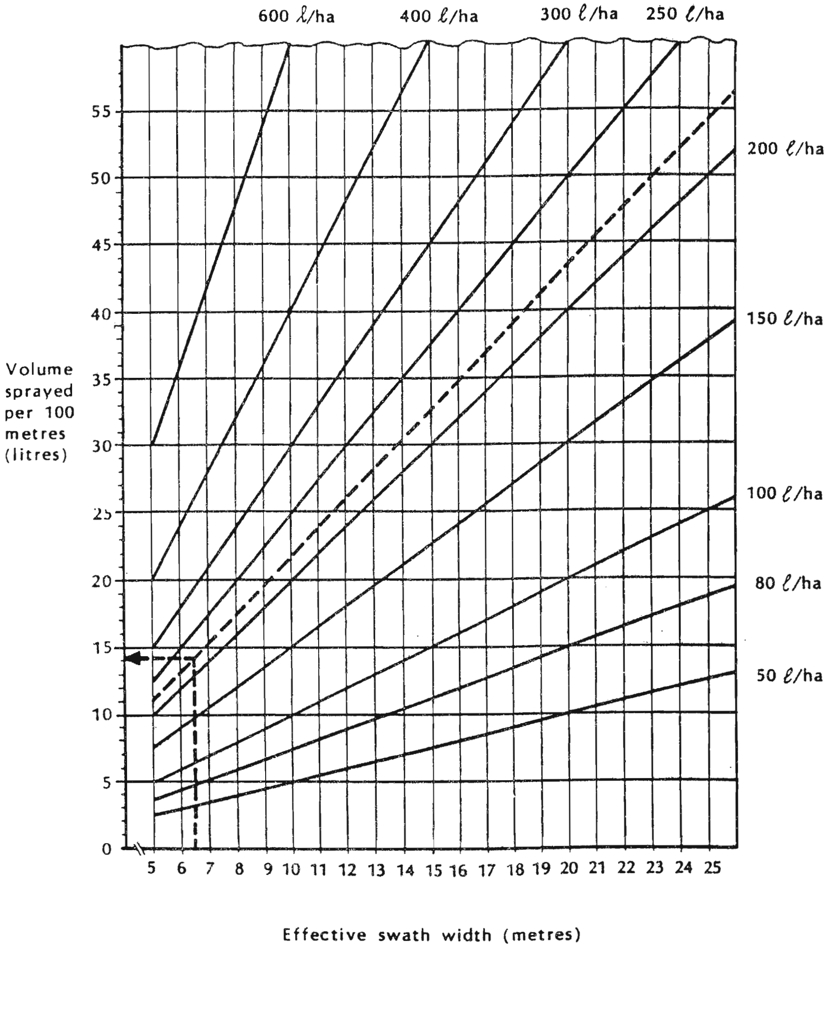
Guidelines:

- The flow rate of the sprayer nozzles should be physically checked with a measuring cylinder and stopwatch.
- Boom height may have to be adjusted to suit crop (see diagram, page E- 57).
- Use a calibration chart such as that included over page to check the sprayer performance, after operating it over a carefully measured distance.
- Calculate *effective swath* = nozzle spacing x number nozzles. If say, the nozzle spacing is 50 cm (0.5 m) and there are 13 nozzles (6 m boom) the effective swath is 50 x 13 = 650 cm or 6.5 m.

** *The manuals for most spray units will contain specifications as to which nozzle type and operating pressure to use for various situations, or a chart to work this out. Directions as to how to calculate application rate on a per ha or per minute basis should also be included.*

Example: *Refer to Calibration Chart[11] below.* With an average speed of 12 km/hr, 100 m (the measured distance) is travelled in 30 seconds. With an effective swath of 6.5 m, and an application rate of, say, 220 litres per ha, the volume applied in 100 metres should be 14 litres. This should be checked against that actually measured from the sprayer.

CALIBRATION CHART



Total volume of application:

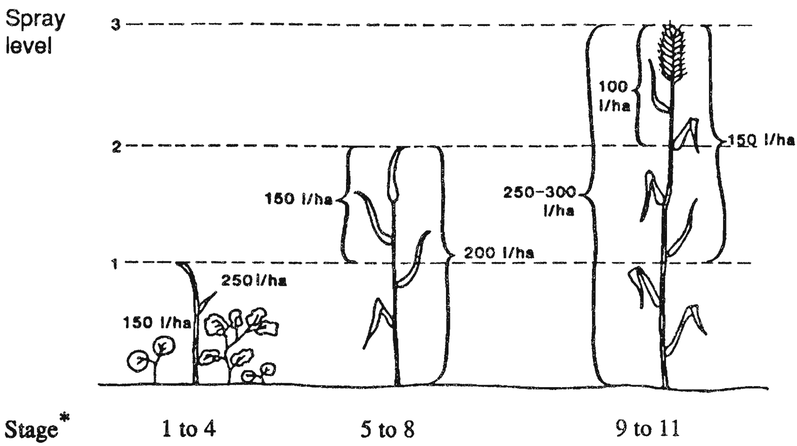
READ THE LABEL to determine the **total** volume to be applied (i.e. chemical plus water).

The following should be used as a guide only[10]:

Spray volume rate:

Herbicides	100 to 300 litre per ha
Fungicides and insecticides	150 to 300 litres per ha

Volume of spray required will also depend on the crop stage and height (see diagram):



* Feekes Scale - see Section 3.2.5 for explanation of this scale.

Amount of Chemical to Use:

$$\text{Rate of Chemical} = \frac{\text{Recommended rate of product/ha x tank capacity}}{\text{total chemical and water per hectare}}$$

For example - "Cereous" should be applied at 500 ml (0.5 litre) per ha in 200 litres water (information from label). If the tank size is 1000 litres the amount of chemical to be added is calculated as follows:

$$\frac{\text{0.5 litres x 1000 litres}}{\text{200 litres per ha}} = \text{2.5 litres}$$

(A full tank will cover 5 ha.)

Spray Unit Cleaning
Immediately after use, sprayers should be thoroughly cleaned to prevent both corrosion of equipment and contamination of crop, when next used. Thorough flushing with water is recommended. This should be done on waste ground or a soakaway area. Extreme care must be taken not to allow this water to enter water races/drains or public sewers.

An appropriate detergent or deactivating agent should be used, (washing soda or ammonia are suitable in most cases).

After certain chemicals have been used further precautions should be taken:

- For example, where the active ingredient is a member of the sulphonyl urea group of chemicals (e.g. Classic, Escort, Express, Glean or Granstar) a chlorine bleach at a rate of 1 litre per 100 litres water should be used. Thorough flushing to remove the chlorine is then essential.

- Where picloram and triclopyr (e.g. Tordon and Dicamba) have been used or any of the phenoxyl group e.g. 2,4-D, 2,4-DB, MCPA/B, Trimec, Salvo (mecroprop/dichlorprop mixtures) an alkaline detergent at a rate of 500 g/100 litres of water should be used to clean the tank.

- As an additional precaution, a one percent solution of ammonia, allowed to stand in the tank for 24 hours (before flushing with clean water) can be used if a hormone sensitive crop is to be sprayed using equipment that has previously contained the above chemicals.

- Wherever possible, separate equipment should be used for different chemical types, especially for hormone sprays or dessicants.

For futher information, consult your chemical company representative, or the New Zealand Agrichemical Manual (for details see Section 2.7.1).

Reducing Wind Drift Effects[10]

Avoid spraying when there is a danger of wind drift.

The effects can be reduced by the following:
- Use larger nozzles.
- Use lower pressure.
- Lower boom height.
- Drive more slowly and where possible, with the wind.
- Use of a chemical additive such as Nalcotrol (recommended for use with herbicides), which acts to decrease the number of fine droplets produced.

Formulas for Calibration of Spray Equipment[10]:

(A) Calculating new pressure:

$$\left(\frac{\text{new output}}{\text{known output}} \right)^2 \times \text{known pressure} = \text{new pressure}$$

(B) Calculating new output:

$$\sqrt{\frac{\text{new pressure}}{\text{known pressure}}} \times \text{known pressure} = \text{new capacity}$$

(C) Spray volume rate:

$$\frac{600 \times \text{litre/min}}{\text{distance (m)} \times \text{km/h}} = \text{litres/ha}$$

(D) Speed:

$$\frac{600 \times \text{litre/min}}{\text{distance (m)} \times \text{l/ha}} = \text{km/hour}$$

(E) Nozzle output:

$$\frac{\text{Distance (m)} \times \text{l/ha} \times \text{km/h}}{600} = \text{l/min}$$

5.8 REFERENCES

1. "Water Consumption of Sheep and Cattle in N.Z.", G. Harrington (1980) N.Z.A.E.I. Project Report 18. (N.Z.A.E.I. - Lincoln University)

2. Sheepyards - "Design and Construction of Sheep Drafting Yards" by J.E. Duncan. N.Z. Department of Agriculture Bulletin, No. 353
N.Z. Farmer, May 23, 1974; January 8, 1976; November 25, 1976; October 13, 1977; May 24, 1979.

3. Covered Yards - M.A.F., N.Z. Farmer, October 1980.

4. Cattleyards - N.Z. Farmer, July 25, 1974; April 14, 1977.

5. Cattlestops - N.Z. Farmer, May 13, 1976.

6. M.A.F. Aglinks FPP 251 (1985) and 252 (1986)

7. M.A.F. Aglinks FPP 570 to 584 inclusive.

8. "Choosing and Using Farm Machines", Brian Whitney (1988) Longman Scientific & Technical, New York.

9. "Profitable farm mechanisation", Claude Culpin (1975) Crosby Lockwood Staples, London.

10. Spray Techniques 674953-GB-89/2 (Hardi-Winstone Publication)

11. "Spray 83" N.Z.A.E.I. (Lincoln University) Publication (1983)

SECTION 6

MEASUREMENTS ON FARM AND FOREST

Sources of Information:

* Ministry of Agriculture and Fisheries

* Ministry of Forestry

* Technical Budget Manual, Lincoln College (1986 edition. Assistance from Natural Resources Engineering Department)

* Various

Compiled by: P.H. Fleming
Farm Management Department.

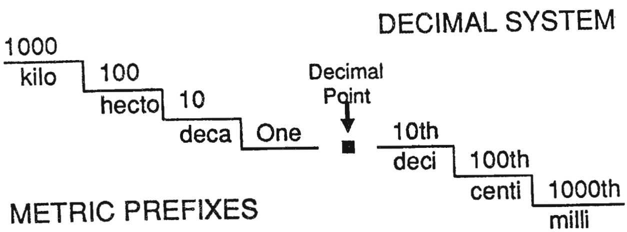
6.1 THE METRIC/DECIMAL SYSTEM

6.1.1 Metric Prefixes

The most common prefixes are:

Prefix	Symbol	Meaning	Factor
giga	G		10^9
mega	M	one million times	10^6
kilo	k	one thousand times	10^3
hecto	h	one hundred times	10^2
deca	da	ten times	10^1
deci	d	one-tenth	10^{-1}
centi	c	one-hundredth	10^{-2}
milli	m	one-thousandth	10^{-3}
micro	μ	one-millionth	10^{-6}

6.1.2 The Decimal System



6.2 QUICK CONVERSIONS - METRIC/IMPERIAL

(see later for detailed conversion tables and additional measures)

1 kg = 2.2046 pounds
1 pound = 0.4536 kilograms
1 kg/ha = 0.8922 lbs/acre
1 lb/acre = 1.121 kg/ha
1 cwt/acre = 125.5 kg/ha
1 metre = 3.281 feet
1 foot = 0.3048 metres
1 kilometre = 0.6214 miles
1 mile = 1.609 kilometres

1 hectare = 2.471 acres
1 acre = 0.4047 hectares
1 hectare = 10,000 sq. metres
1 sq. km = 100 hectares
1 sq. mile = 259 hectares
1 cu. yard = 0.7646 cu. metres
1 cu. metre = 1.308 cu. yards
= 35.42 cu.ft
1 gallon = 4.546 litres

6.3 AREA/SQUARE MEASURE

6.3.1 Imperial/Metric Conversions of Area

Calculations Involved:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
square inch	square centimetre	1 in^2 = 6.452 cm^2	1 cm^2 = 0.155 in^2
square foot	square centimetre	1 ft^2 = 929 cm^2	
or	square metre	1 ft^2= 0.0929 m^2	1 m^2 = 10.76 ft^2
square yard	square metre	1 yd^2 = 0.8361 m^2	1 m^2 = 1.196 yd^2
perch	square metre	1 p = 25.29 m^2	1 m^2 = 0.03954 p
rood	hectare	1 rd = 0.101 ha	1 ha = 9.88 rd
	(1 hectare = 10,000 sq. m; a square with sides of 100m).		
acre	hectare	1 ac = 0.4047 ha	1 ha = 2.471 ac
square mile	square kilometre (1 sq. km = 100 ha)	1 sq mile = 2.59 km^2	1 km^2 = 0.3861 sq.miles

Tables:

SQUARE FEET TO SQUARE METRES

Table A: 1 - 9 sq.ft

Sq Ft	1	2	3	4	5	6	7	8	9
	Square Metres								
	0.09	0.19	0.28	0.37	0.47	0.56	0.65	0.74	0.84

Table B : 10 - 900 sq.ft ***Example: 550 sq.ft = 51.10 sq.m***

Sq Ft	0	10	20	30	40	50	60	70	80	90
	Square Metres									
0		0.93	1.86	2.79	3.72	4.65	5.57	6.50	7.43	8.36
100	9.29	10.22	11.15	12.08	13.01	13.94	14.86	15.79	16.72	17.65
200	18.58	19.51	20.44	21.37	22.30	23.23	24.15	25.08	26.01	26.94
300	27.87	28.80	29.73	30.66	31.59	32.52	33.45	34.37	35.30	36.23
400	37.16	38.09	39.02	39.95	40.88	41.81	42.74	43.66	44.59	45.52
500	46.45	47.38	48.31	49.24	50.17	**51.10**	52.03	52.95	53.88	54.81
600	55.74	56.67	57.60	58.53	59.46	60.39	61.32	62.24	63.17	64.10
700	65.03	65.96	66.89	67.82	68.75	69.68	70.61	71.54	72.46	73.39
800	74.32	75.25	76.18	77.11	78.04	78.97	79.90	80.83	81.75	82.68
900	83.61	84.54	85.47	86.40	87.33	88.26	89.19	90.12	91.04	91.97

ACRES TO HECTARES

Table A: 1 - 9 acres

Acres	1	2	3	4	5	6	7	8	9
	Hectares								
	0.405	0.810	1.215	1.620	2.025	2.430	2.835	3.240	3.645

Table B : 10 - 1000 acres ***Example: 550 acres = 222.6 ha***

Acres	0	10	20	30	40	50	60	70	80	90
	Hectares									
0		4.0	8.1	12.1	16.2	20.2	24.3	28.3	32.4	36.4
100	40.5	44.5	48.6	52.6	56.7	60.7	64.7	68.8	72.8	76.9
200	80.9	85.0	89.0	93.1	97.1	101.2	105.2	109.3	113.3	117.4
300	121.4	125.5	129.5	133.5	137.6	141.6	145.7	149.7	153.8	157.8
400	161.9	165.9	170.0	174.0	178.1	182.1	186.2	190.2	194.2	198.3
500	202.3	206.4	210.4	214.5	218.5	**222.6**	226.6	230.7	234.7	238.9
600	242.8	246.9	250.9	255.0	259.0	263.0	267.1	271.1	275.2	279.2
700	283.3	287.3	291.4	295.4	299.5	303.5	307.6	311.6	315.7	319.7
800	323.7	327.8	331.8	335.9	339.9	344.0	348.0	352.1	356.1	360.2
900	364.2	368.3	372.3	376.4	380.4	384.5	388.5	392.5	396.6	400.6
1000	404.7									

6.3.2 Imperial Measures of Area

144 sq. inches	=	1 square foot
9 sq. ft	=	1 square yard
30.25 sq. yards	=	1 square pole or perch
40 sq. perches	=	1 rood
4 roods	=	1 acre
640 acres	=	1 square mile
1 sq. chain	=	10,000 sq. links
	=	484 sq. yards
8 ft x 1 mile	=	1 acre
10 sq. chains	=	1 acre

Note: See Section 6.3.1 for metric conversions.

6.4 TOPDRESSING/SOWING/HARVESTING MEASURES (MASS PER UNIT AREA)

(see also section 6.16, Bushell Conversions; and section 6.8, Spraying Rates).

6.4.1 Imperial/Metric Conversions

Calculations involved:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
ounce/yard^2	gram/metre^2	1 oz/yard^2 = 33.91 g/m^2	1 g/m^2 = 0.0295 oz/yard^2
pound/acre	gram/metre^2	1 lb/acre = 0.1121 g/m^2	1 g/m^2 = 8.922 lb/acre
or	kilogram/hectare	1 lb/acre = 1.121kg/ha	1 kg/ha = 0.8922 lb/acre
hundredweight per acre	tonnes/ha	1 cwt/acre= 0.1255 t/ha = 125.5 kg/ha	1 t/ha = 7.97 cwt/acre

Tables:

POUNDS PER ACRE TO KILOGRAMS PER HECTARE

Table A: Fraction of lb/acre

Lb/Acre		1/4	1/2	3/4
	Kilograms Per Hectare			
		0.280	0.561	0.841

Table B : 1 - 99 lb/acre ***Example: 44 lb/acre = 49.3 kg/ha***

Lb/Acre	0	1	2	3	4	5	6	7	8	9
	Kilograms/Hectare									
0		1.1	2.2	3.4	4.5	5.6	6.7	7.8	9.0	10.1
10	11.2	12.3	13.5	14.6	15.7	16.8	17.9	19.1	20.2	21.3
20	22.4	23.5	24.7	25.8	26.9	28.0	29.1	30.3	31.4	32.5
30	33.6	34.7	35.9	37.0	38.1	39.2	40.4	41.5	42.6	43.7
40	44.8	46.0	47.1	48.2	**49.3**	50.4	51.6	52.7	53.8	54.9
50	56.0	57.2	58.3	59.4	60.5	61.6	62.8	63.9	65.0	66.1
60	67.3	68.4	69.5	70.6	71.7	72.9	74.0	75.1	76.2	77.3
70	78.5	79.6	80.7	81.8	82.9	84.1	85.2	86.3	87.4	88.5
80	89.7	90.8	91.9	93.0	94.2	95.3	96.4	97.5	98.6	99.8
90	100.9	102.0	103.1	104.2	105.4	106.5	107.6	108.7	109.8	111.0

HUNDREDWEIGHTS PER ACRE TO KILOGRAMS PER HECTARE

Table A: Fraction of cwt/acre

Cwt/Acre	1/4	1/2	3/4
	Kilograms/Hectare		
	31.38	62.75	94.13

Table B : 1 - 19 cwt/acre ***Example: 2 cwt/acre = 251 kg/ha***

Cwt/Acre	0	1	2	3	4	5	6	7	8	9
	Kilograms Per Hectare									
0		126	**251**	377	502	628	753	879	1004	1130
10	1255	1381	1506	1632	1758	1883	2009	2134	2260	2385

TONS PER ACRE TO TONNES PER HECTARE

Ton/Acre	0	1	2	3	4	5	6	7	8	9
	Tonnes/Hectare									
		2.5	5.0	7.5	10.0	12.6	15.1	17.6	20.1	22.6

6.5 LENGTH/DISTANCE MEASURES

6.5.1 Imperial/Metric Conversions of Length

Calculations involved:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
inch	millimetre	1 in = 25.4 mm	1 mm = 0.03937 in
or	centimetre(=10mm)	1 in = 2.54 cm	1 cm = 0.3937 in
foot	metre (=1000mm)	1 ft = 0.3048 m	1 m = 3.281 ft
yard	metre	1 yd = 0.9144 m	1 m = 1.094 yards
chain	metre	1 chain = 20.12 m	1 m = 0.04971 chain
furlong	metre	1 furlong = 201.2 m	1 m = 0.004971 furlong
mile	kilometre	1 mile = 1.609 km	1 km = 0.6214 mile = 4.971 furlongs

Tables:

FRACTIONS OF INCHES AND INCHES TO MILLIMETRES

Inches	mm	Inches	mm	Inches	mm	Inches	mm
1/16	1.6	1/2	12.7	1	25	8	203
1/8	3.2	9/16	14.3	2	51	9	229
3/16	4.8	5/8	15.9	3	76	10	254
1/4	6.4	11/16	17.5	4	102	11	279
5/16	7.9	3/4	19.1	5	127	12	305
3/8	9.5	13/16	20.6	6	152		
7/16	11.1	7/8	22.2	7	178		

FEET TO METRES ***Example: 24 ft = 7.32 metres***

Feet	0	1	2	3	4	5	6	7	8	9
	Metres									
0		0.31	0.61	0.91	1.22	1.52	1.83	2.13	2.44	2.74
10	3.05	3.35	3.66	3.96	4.27	4.57	4.88	5.18	5.49	5.79
20	6.10	6.40	6.71	7.01	**7.32**	7.62	7.93	8.23	8.53	8.84
30	9.14	9.45	9.75	10.06	10.36	10.67	10.97	11.28	11.58	11.89
40	12.19	12.50	12.80	13.11	13.41	13.72	14.02	14.33	14.63	14.94
50	15.24									

YARDS TO METRES ***Example: 540 yards = 493.8 metres***

Yards	0	10	20	30	40	50	60	70	80	90
	Metres									
0		9.1	18.3	27.4	36.6	45.7	54.9	64.0	73.2	82.3
100	91.4	100.6	109.7	118.9	128.0	137.2	146.3	155.5	164.6	173.7
200	182.9	192.0	201.2	210.3	219.5	228.6	237.7	246.9	256.0	265.2
300	274.3	283.4	292.6	301.8	310.9	320.0	329.2	338.3	347.5	356.6
400	365.8	374.9	384.1	393.2	402.3	411.5	420.6	429.8	438.9	448.1
500	457.2	466.3	475.5	484.6	**493.8**	502.9	512.1	521.2	530.4	539.5
600	548.6	557.8	566.9	576.1	585.2	594.4	603.5	612.7	621.8	630.9
700	640.1	649.2	658.4	667.5	676.7	685.8	694.9	704.1	713.2	722.4
800	731.5	740.7	749.8	759.0	768.1	777.2	786.4	795.5	804.7	813.8
900	823.0	832.1	841.3	850.4	859.5	868.7	877.8	887.0	896.1	905.3

CHAINS TO METRES ***Example: 44 chains = 885 metres***

Chains	0	1	2	3	4	5	6	7	8	9
	Metres									
0		20	40	60	81	101	121	141	161	181
10	201	221	241	262	282	302	322	342	362	382
20	402	423	443	463	483	503	523	543	563	583
30	604	624	644	664	684	704	724	744	764	785
40	805	825	845	865	**885**	905	925	946	966	986
50	1006	1026	1046	1066	1086	1106	1127	1147	1167	1187
60	1207	1227	1247	1267	1288	1308	1328	1348	1368	1388
70	1408	1428	1448	1469	1489	1509	1529	1549	1569	1589
80	1609	1630	1650	1670	1690	1710	1730	1750	1770	1790
90	1810	1831	1851	1871	1891	1911	1931	1951	1971	1992

MILES TO KILOMETRES ***Example: 24 miles = 38.62 km***

Miles	0	1	2	3	4	5	6	7	8	9
	Kilometres									
0		1.61	3.22	4.83	6.44	8.05	9.66	11.27	12.87	14.48
10	16.09	17.70	19.31	20.92	22.53	24.14	25.75	27.36	28.97	30.58
20	32.19	33.80	35.41	37.01	**38.62**	40.23	41.84	43.45	45.06	46.67
30	48.28	49.89	51.50	53.11	54.72	56.33	57.94	59.55	61.16	62.76
40	64.37	65.98	67.59	69.20	70.81	72.42	74.03	75.64	77.25	78.86
50	80.47									

6.5.2 Imperial Measures of Length

4 inches	=	1 hand (10 cm)
9 inches	=	1 span
12 inches	=	1 foot
3 feet	=	1 yard
6 feet	=	1 fathom
5.5 yards	=	1 rod, pole or perch
4 poles	=	1 chain (22 yards)
10 chains	=	1 furlong
8 furlongs	=	1 mile (80 chains)
3 miles	=	1 league
1 link	=	7.92 inches
1 chain	=	100 links (22 yards)
1 mile	=	80 chains (1760 yards)
1 Nautical or Geographical mile	=	6080 feet
Cables length	=	600 feet
A degree (at equator)	=	60 geographical or 69.121 statute miles

Note: See Section 6.5.1 for metric conversions.

6.6 WEIGHT (MASS) MEASURES

6.6.1 Imperial/Metric Conversions of Weight

Calculations involved:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
ounce	gram	1 oz = 28.35 g	1 g = 0.03527 oz
pound	kilogram	1 lb = 0.4536 kg	1 kg = 2.205 lb
hundredweight	kilogram	1 cwt = 50.80 kg	1 kg = 0.01968 cwt
ton (long)	tonne (1 tonne = 1000 kg)	1 ton (long)=1.016 tonnes	1 tonne=0.9842 tons (long)
ton (short)	tonne	1 ton (short)=0.9072 tonnes	1 tonne=1.1023 tons (short)

Note: see also section 6.7.2, weight of water, milk; also section 6.16 bushell weights.

Tables:

OUNCES TO GRAMS

Ounces	0	1	2	3	4	5	6	7	8	9
	Grams									
0		28.4	56.7	85.0	113.4	141.7	170.1	198.4	226.8	255.1
10	283.5	311.8	340.2	368.5	396.9	425.2	453.6	481.9	510.3	538.6

POUNDS TO KILOGRAMS

Table A: 1 - 9 Pounds

Pounds	1	2	3	4	5	6	7	8	9
Kilograms									
	0.454	0.907	1.361	1.814	2.268	2.722	3.175	3.629	4.082

See also Table B (over page)

Table B : 10 - 990 lbs ***Example: 540 lb = 244.9 kg***

Pounds	0	10	20	30	40	50	60	70	80	90
	Kilograms									
0		4.5	9.1	13.6	18.1	22.7	27.2	31.8	36.3	40.8
100	45.4	49.9	54.4	59.0	63.5	68.0	72.6	77.1	81.6	86.2
200	90.7	95.3	99.8	104.3	108.9	113.4	117.9	122.5	127.0	131.5
300	136.1	140.6	145.1	149.7	154.2	158.8	163.3	167.8	172.4	176.9
400	181.4	186.0	190.5	195.0	199.6	204.1	208.7	213.2	217.7	222.3
500	226.8	231.3	235.9	240.4	**244.9**	249.5	254.0	258.5	263.1	267.6
600	272.2	276.7	281.2	285.8	290.3	294.8	299.4	303.9	308.4	313.0
700	317.5	322.1	326.6	331.1	335.7	340.2	344.7	349.3	353.8	358.3
800	362.9	367.4	371.9	376.5	381.0	385.6	390.1	394.6	399.2	403.7
900	408.2	412.8	417.3	421.8	426.4	430.9	435.4	440.0	444.5	449.1

HUNDREDWEIGHTS TO KILOGRAMS

Cwt	0	1	2	3	4	5	6	7	8	9
	Kilograms									
0		51	102	152	203	254	305	356	406	457
10	508	559	610	660	711	762	813	864	914	965
20	1016									

TONS TO TONNES

Example: 54 tons = 54.87 tonnes

Ton(s)	0	1	2	3	4	5	6	7	8	9
	Tonnes									
0		1.02	2.03	3.05	4.06	5.08	6.10	7.11	8.13	9.14
10	10.16	11.18	12.19	13.21	14.22	15.24	16.26	17.27	18.29	19.30
20	20.32	21.34	22.35	23.37	24.39	25.40	26.42	27.43	28.45	29.47
30	30.48	31.50	32.51	33.53	34.55	35.56	36.58	37.59	38.61	39.63
40	40.64	41.66	42.67	43.69	44.71	45.72	46.74	47.75	48.77	49.79
50	50.80	51.82	52.83	53.85	**54.87**	55.88	56.90	59.91	58.93	59.95
60	60.96	61.95	62.99	64.01	65.03	66.04	67.06	68.08	69.09	70.11
70	71.12	72.14	73.16	74.17	75.19	76.20	77.22	78.24	79.29	80.27
80	81.28	82.30	83.32	84.33	85.35	86.36	87.38	88.40	89.41	90.43
90	91.44	92.46	93.48	94.49	95.51	96.52	97.54	98.56	99.57	100.6

6.6.2 Imperial Measurements of Weight

Note: see also Volume/Imperial

7000 grains	=	1 pound (lb.)
16 drams	=	1 ounce (oz.)
16 ounces	=	1 pound (lb.)
14 pounds	=	1 stone (st.)
28 pounds	=	1 quarter (qr.)
4 quarters	=	1 hundredweight (cwt.)
112 pounds	=	1 hundredweight (cwt.)
20 cwt	=	1 ton (long)
1 cental	=	100 pounds
1 short ton	=	2000 pounds
1 long ton	=	2240 pounds

Note: See Section 6.6.1 for metric conversions

6.7 VOLUME/CUBIC MEASURE/CAPACITY

[Note: See also section 6.9, Flow Rate (Volume/Time)]

6.7.1 Imperial/Metric Conversions of Volume/Capacity

Calculations involved:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
cubic foot	cubic metre	1 cu. ft = 0.02832 m^3	1 m^3 = 35.32 cu. ft
cubic yard	cubic metre	1 cu. yd = 0.7646 m^3	1 m^3 = 1.308 cu. yds
	(1 cubic metre = 1000 litres = 220 gallons)		
pint	litre	1 pint = 0.58683 litres	1 litre = 1.76 pints
gallon	litre	1 gal. = 4.546 litres	1 litre = 0.220 gal.
	(1 litre = 1000 ml or 1000 cubic centimetres or 0.001 m^3)		
fluid ounce	millilitre	1 fl.oz. = 28.41 ml	1 ml = 0.0352 fl.oz.

(20 fluid ounces = 1 pint)

Note:
1 teaspoonful = 3.5 ml
1 dessertspoonful = 7.0 ml
1 tablespoonful = 14.0 ml

Tables:

GALLONS TO LITRES

Table A: 1 - 9 Gallons

Gals		1	2	3	4	5	6	7	8	9
	Litres									
		4.5	9.1	13.6	18.2	22.7	27.3	31.8	36.4	40.9

See also Table B (next page)

Table B 10 - 990 gallons ***Example: 540 gals = 2455 l***

Gals	0	10	20	30	40	50	60	70	80	90
	Litres									
0		45	91	136	182	227	273	318	364	409
100	455	500	546	591	636	682	727	773	818	864
200	909	955	1000	1046	1091	1137	1182	1227	1273	1318
300	1364	1409	1455	1500	1546	1591	1637	1682	1728	1773
400	1818	1864	1909	1955	2000	2046	2091	2137	2182	2228
500	2273	2319	2364	2409	**2455**	2500	2546	2591	2637	2682
600	2728	2773	2819	2864	2909	2955	3000	3046	3091	3137
700	3182	3228	3273	3319	3364	3410	3455	3500	3546	3591
800	3637	3682	3728	3773	3819	3864	3910	3955	4001	4046
900	4091	4137	4182	4228	4273	4319	4364	4410	4455	4501

CUBIC FEET TO CUBIC METRES

Table A: 1 - 9 Cubic Feet

Cubic Feet	1	2	3	4	5	6	7	8	9
	Cubic Metres								
	0.03	0.06	0.09	0.11	0.14	0.17	0.20	0.23	0.25

Table B : 10 - 990 cubic feet ***Example 540 cu.ft = 15.29 cu.m***

Cubic Feet	0	10	20	30	40	50	60	70	80	90
	Cubic Metres									
0	0	0.28	0.57	0.85	1.13	1.42	1.70	1.98	2.27	2.55
100	2.83	3.11	3.40	3.68	3.96	4.25	4.53	4.81	5.10	5.38
200	5.66	5.95	6.23	6.51	6.80	7.08	7.36	7.65	7.93	8.21
300	8.50	8.78	9.06	9.34	9.63	9.91	10.19	10.48	10.76	11.04
400	11.33	11.61	11.89	12.18	12.46	12.74	13.03	13.31	13.59	13.88
500	14.16	14.44	14.72	15.01	**15.29**	15.57	15.86	16.14	16.42	16.71
600	16.99	17.27	17.56	17.84	18.12	18.41	18.69	18.97	19.26	19.54
700	19.82	20.10	20.39	20.67	20.95	21.24	21.52	21.80	22.09	22.37
800	22.65	22.94	23.22	23.50	23.79	24.07	24.35	24.64	24.92	25.20
900	25.49	25.77	26.05	26.33	26.62	26.90	27.18	27.47	27.75	28.03

6.7.2 Imperial Measure of Volume/Solid Measure

Volume
60 minims = 1 fluid drachm (dram)
8 fluid drachms = 1 fluid ounce
20 fluid ounces = 1 pint
34.68 cu.in = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
1 fluid ounce = 437.5 grains
1 cubic foot of water weighs 1000 oz. or 62.5 lb.
1 cubic foot of water = 6.25 gallons
1 gallon of water weighs 10 lb.
1 gallon of milk weighs 10.5 lb (nearly).
1 inch of rainfall = 22,622 gallons or 100.9 tons per acre
1 bushell (dry measure) = 8 gallons
1 peck = 2 gallons
1 quarter = 8 bushells

Cubic or Solid Measure
1728 cubic inches = 1 cubic foot
27 cubic feet = 1 cubic yard
A cord of wood = 4ft x 4ft x 8ft = 128 cubic ft
A shipping ton = 42 cubic feet of timber
" " " = 40 cubic feet of freight
Ship's tons of displacement = 35 cubic feet

Note: See Section 6.7.1 for metric conversions.

6.8 SPRAYING RATES: VOLUME/AREA

(Note: see also Section 6.13, Density Measures/Spraying Mixtures)

Imperial/Metric Conversion Calculations:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
fluid ounce/acre	millilitres/hectare	1 fl.oz/ac = 70.2 ml/ha	1 ml/ha = 0.014 fl.oz/ac
pint/acre	litre/hectare	1 pint/acre = 1.404 l/ha	1 l/ha = 0.7121 pint/acre
gallon/acre	litre/hectare	1 gal./acre = 11.23 l/ha	1 l/ha = 0.08902 gal/acre

Tables:

FLUID OUNCES PER ACRE TO MILLILITRES PER HECTARE

Fluid oz / Acre	0	1	2	3	4	5	6	7	8	9
	Millilitres/hectare									
0		70	140	210	280	350	420	490	560	630
10	700	770	840	910	980	1050	1120	1190	1260	1330
20	1400	1470	1540	1610	1680	1750	1820	1890	1960	2030

PINTS PER ACRE TO LITRES PER HECTARE

Pints Per Acre	0	1	2	3	4	5	6	7	8	9
	Litres/Hectare									
0		1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6
10	14.0	15.4	16.9	18.3	19.7	21.1	22.5	23.9	25.3	26.7

GALLONS PER ACRE TO LITRES PER HECTARE

Table A: 1-99 Gal/Acre ***Example: 44 gal/acre = 494.3 l/ha***

Gal/ Acre	0	1	2	3	4	5	6	7	8	9
	Litres/hectare									
0		11.2	22.5	33.7	44.9	56.2	67.4	78.6	89.9	101.1
10	112.3	123.6	134.8	146.0	157.3	168.5	179.7	191.0	202.2	213.4
20	224.7	235.9	247.1	258.4	269.6	280.8	292.1	303.3	314.5	325.8
30	337.0	348.2	359.5	370.7	381.9	393.2	404.4	415.6	426.9	438.1
40	449.3	460.6	471.8	483.0	**494.3**	505.5	516.7	528.0	539.2	550.4
50	561.7	572.9	584.1	595.4	606.6	617.9	629.1	640.3	651.6	662.8
60	674.0	685.3	696.5	707.7	719.0	730.2	741.4	752.7	763.9	775.1
70	786.4	797.6	808.8	820.1	831.3	842.5	853.8	865.0	876.2	887.5
80	898.7	909.9	921.2	932.4	943.6	954.9	966.1	977.3	988.6	999.8
90	1011	1022	1034	1045	1056	1067	1078	1090	1101	1112

Table B: 100 - 400 gal/acre

Gal/ Acre	100	200	400
	Litres/hectare		
	1123	2247	4493

6.9 FLOW RATE (VOLUME/TIME)

(See also section 6.7, Volume Measures)

Imperial/Metric Conversions:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
cubic feet/second (= cusec)	cubic metre/second	1 cu.ft/s=0.0283 m^3/s	1 m^3/s=35.31 cu.ft/s
	(1 cubic metre/second = 1 cumec = 1000 litres/second)		
cubic feet/second	cubic metre/hour	1 cu.ft/s=101.9m^3/hr	1 m^3/hr=0.0098 cu.ft/s
gallon/hour	cubic metre/hour	1 gal/hr=0.004546 m^3/hr	1 m^3/hr=219.97 gal/hr
cubic foot/second	litres/second	1 cu.ft/s=28.32 l/s	1 l/s=0.03531cu.ft/s
gallon/minute	litres/hour	1 gal/min=272.8 l/hr	1 l/hr=0.0037 gal/min
gallon/hour	litres/hour	1 gal/hour=4.546 l/hr	1 l/hr=0.22 gal/hr

6.10 RAINFALL/IRRIGATION

(See also section 6.7, Volume; and 6.8, Spray Rates)

Imperial	Metric
1 inch rain = 100 points	= 25.4 mm
1 acre inch = 22,622 gallons/acre	= 254117 litres/ha
(1 acre inch of rain or irrigation)	
1 acre foot = 271,464 gallons per acre	= 3049 m^3/ha

Note: Metric/Irrigation

The unit for depth of irrigation is the millimetre.

1 mm (depth) = 1 litre/m^2 = 10 m^3/ha

(i.e. 1 mm water applied to 1 ha = 10m^3 volume of water).

6.11 POWER/ENERGY/ELECTRICITY MEASURES

6.11.1 Energy/Power Measures

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
horsepower	kilowatt	1 hp = 0.7457 kW	1 kW = 1.341 hp
kilocalorie	kilojoule	1 kc = 4.187 kJ	1kJ = 0.239 kc

Note: see below for electrical terms and measures.

HORSEPOWER TO KILOWATTS
Table A: 1 - 9 Horsepower

Hp	1	2	3	4	5	6	7	8	9
	Kilowatts								
	0.746	1.491	2.237	2.983	3.729	4.474	5.220	5.966	6.711

Table B: 10 - 290 Horsepower

Hp	0	10	20	30	40	50	60	70	80	90
	Kilowatts									
0		7.5	14.9	22.4	29.8	37.3	44.7	52.2	59.7	67.1
100	74.6	82.0	89.5	96.9	104.4	111.9	119.3	126.8	134.2	141.7
200	149.1	156.6	164.1	171.5	179.0	186.4	193.9	201.3	208.8	216.2

6.11.2 Electrical Terms and Measures

Ampere......................the unit in which the strength of an electrical current is measured.

Ohm..........................the unit in which resistance to the flow of an electric current is measured.

Volt...........................the unit of electric 'pressure'. A 'pressure' of 1 volt is required to 'force' a current of 1 amp through a resistance of 1 ohm.

Watt..........................the unit of power, or a rate of doing work.
Watts = Volts x Amperes.
The Watt is the power used when work is done or energy expended at the rate of 1 joule per second.

Kilowatt-hour............for commercial purposes, electrical energy is charged for in units of 1000 watt-hours, or kilowatt-hours.
1 kW uses 1 "unit" of electricity per hour.

$$\text{kW-h for D.C. current} = \frac{\text{Volts x Amperes x hours}}{1000}$$

$$\text{kW-h for A.C. current} = \frac{\text{Volts x Amperes x hours x power factor}}{1000}$$

$$\text{No. of kilowatts to heat water in 1 hour} = \frac{\text{litres x Temperature Rise } (^{o}\text{C})}{\text{8.856 x Efficiency Pecentage}}$$

Note: With water at an average tap temperature of 10^{o}C, 1 kW will boil 9.54 litres/hour at 100% efficiency.

6.12 PRESSURE

(see also section 6.13, Density Measures).

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
pound/inch^2	kilopascal	1 psi = 6.895 kPa	1 kPa = 0.145 psi (lb/in^2) 1 kPa = 0.102 m head.

Note: see below for Hydraulic Head

Tables:

POUNDS PER SQUARE INCH TO KILOPASCALS

Table A: 1 - 9 p.s.i.

PSI		1	2	3	4	5	6	7	8	9
	Kilopascals									
		6.9	13.8	20.7	27.6	34.5	41.4	48.3	55.2	62.1

Table B: 10 - 290 p.s.i. ***Example: 140 psi = 965 kPa***

PSI	0	10	20	30	40	50	60	70	80	90
	Kilopascals									
0		69	138	207	276	345	414	483	552	621
100	689	758	827	896	**965**	1034	1103	1172	1241	1310
200	1379	1448	1517	1586	1655	1724	1793	1862	1931	1999

Hydraulic Head

1 m head = 3.2808 ft.head
= 9.8 kPa
= 1.42 lb/in^2 (psi)

6.13 DENSITY MEASURES/SPRAYING MIXTURES

6.13.1 Imperial/Metric Conversions of Density

Calculation Involved:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
pound/cubic inch	grams/cubic centimetre	1 lb/in^3 = 27.68 g/cm^3	1 g/cm^3 = 0.0361 lb/in^3
pound/cubic foot	grams/cubic centimetre	1 lb/ft^3 = 0.01602 g/cm^3	1 g/cm^3 = 62.43 lb/ft^3
pound/cubic foot	kilograms/cubic metre	1 lb/ft^3 = 16.02 kg/m^3	1 kg/m^3 = 0.0624 lb/ft^3
ounce/gallon	grams/litre	1 oz/gallon = 6.236 g/l	1 g/l = 0.16 oz/gal
pound/gallon	grams/litre	1 lb/gallon = 99.78 g/l	1 g/l = 0.01 lb/gallon

Tables:

OUNCES PER 100 GALLONS TO GRAMS PER 100 LITRES

Oz /100 Gal	0	1	2	3	4	5	6	7	8	9
	Grams/100 Litres									
0		6.24	12.47	18.71	24.94	31.18	37.42	43.65	49.89	56.12
10	62.36	68.60	74.83	81.07	87.30	93.54	99.78	106.0	112.3	118.5

Note: 20 fluid ounces are equal to one pint.

PINTS PER 100 GALLONS TO MILLILITRES PER 100 LITRES

Pints /100 Gal	0	1	2	3	4	5	6	7	8	9
	Millilitres/100 Litres									
0		125	250	375	500	625	750	875	1000	1125
10	1250	1375	1500	1625	1750	1875	2000	2125	2250	2375

6.14 SPEED/VELOCITY MEASURES

Imperial/Metric Conversions of Speed:

Imperial Unit	Metric Unit	Imperial to Metric Units	Metric to Imperial Units
foot/second	metres/second	1 ft/s = 0.304 m/s	1 m/s = 3.281 ft/s
foot/second	kilometres/hour	1 ft/s = 1.0973 km/h	1 km/h = 0.9113 ft/s
mile/hour	metres/second	1 mph = 0.447 m/s	1 m/s = 2.237 mph
mile/hour	kilometres/hour	1 mph = 1.609 km/h	1 km/h = 0.6214 mph

6.15 TEMPERATURE - FAHRENHEIT AND CELCIUS CONVERSIONS:

To convert temperatures:

Celsius to Fahrenheit:
9 ÷ 5 x ^{O}C +32 = Fahrenheit [example: 9 ÷ 5 x **20^{O}C** +32 = **68^{O}F**]

Fahrenheit to Celsius:
5 ÷ 9 x (^{O}F-32) = Celsius [example: (**50^{O}F**-32) x 5 ÷ 9 = **10^{O}C**]

Fahrenheit : Water boils (under standard conditions) at 212^{O}F and freezes at 32^{O}F.
Celsius or centigrade : Water boils at 100^{O}C and freezes at 0^{O}C.

6.16 BUSHELL CONVERSIONS

(See also section 6.7.2, bushell volume)

6.16.1 Bushells Per Acre to Kilograms (Tonnes) Per Hectare for Various Crops

Crop	Ryegrass Seed	Oats	Barley	Maize	Peas/Wheat
Bushell Weight - lb (approx.) - kg	20 9.1	40 18.1	50 22.7	56 25.4	60 27.2
Bushell/Acre	Kilograms or Tonnes Per Hectare (approx.)				
20	450	900	1.0	1.3	1.3
30	670	1.4	1.7	1.9	2.0
40	900	1.8	2.2	2.5	2.7
50	1120	2.2	2.8	3.1	3.4
60	1350	2.7	3.4	3.8	4.0
70	1570	3.1	3.9	4.4	4.7
80	1800	3.6	4.5	5.0	5.4
90	-	4.0	5.0	5.6	6.1
100	-	4.5	5.6	6.3	6.7
120	-	5.4	6.7	7.5	8.1
140	-	6.3	7.9	8.8	9.4
160	-	7.2	9.0	10.0	10.8
180	-	-	10.1	11.3	-
200	-	-	-	12.6	-

6.16.2 Bushell Weights of Crops/Seeds

	Weight Pounds (lbs)	 Kilograms (kg)
Barley	50	22.68
Beans (dry, haricot)	65	29.48
Clovers	60	27.22
Cocksfoot (machine dressed)	17	7.71
Linseed	56	25.40
Lucerne	60	27.22
Lupins	60	27.22
Maize	56	25.40
Oats	40	18.14
Peas (dry)	60	27.22
Peas in pod	28	12.70
Rye (ryecorn)	56	25.40
Ryegrass (machine dressed)	20	9.07
Wheat	60	27.22

6.17 LAND AREA AND DISTANCE ON HILL SLOPES

(See also Section 5.3, Fencing)

6.17.1 Calculations to determine *actual* area and distance from farm plans or aerial photographs.

Table 1:			
Degree of slope	Natural Secant	Degree of slope	Natural Secant
0^{o}	1.0000	30^{o}	1.1547
5^{o}	1.0038	35^{o}	1.2207
10^{o}	1.0154	40^{o}	1.3054
15^{o}	1.0352	45^{o}	1.4142
20^{o}	**1.0641**	50^{o}	1.5560
25^{o}	1.1033	60^{o}	2.0000

Examples: Hill country - average slope say 20^{o}.

1. Area: Farm Plan area of 100 hectares = 100 x 1.0641
= 106.4 hectares on slope

2. Distance: 1 km fence on plan = 1 x 1.0641
= 1.064 km on slope (1064 metres)

3. Effective rate of fertiliser application: apply @ 200 kg per ha (plan area)
= 200 ÷ 1.0641
= 188 kg/ha on slope.

Note: At 60^{o} slope the areas double and the effective rate of fertiliser application is only half. However slopes greater than 45^{o} are very rare on farmable land. As a guide the following table should be helpful (see next page):

Table 2:			
Class of Hill Country	Degree of Average Slope	Increase in Area or Length Fence	Effective Rate of Fertiliser Application @ 200 Kg/ha
Easy	10^{o}	1.5%	197 Kg/ha
Moderate Steep	**20^{o}**	**6.4% (0.0641)**	**188 Kg**
Steep	30^{o}	15.5%	173 Kg
Very Steep	40^{o}	30.5%	153 Kg
Unfarmable	60^{o}	100.0%	100 Kg

6.18 FINANCE MEASURES

6.18.1 Cost of Servicing Table Mortgages

(Annual Payments on Amortized Loans with Equal Total Payments).
The annual payment (interest and principal combined) per $1000 borrowed on table mortgage is set out below:

Repayments of Interest and Principal (Per $1000 Borrowed)

Terms of Loan:

	Years (Mortgage Term)				
	5	**10**	**15**	**20**	**25**
Interest Rate	$ p.a.	$ p.a.	$ p.a.	$ p.a.	$ p.a.
5%	230.97	129.50	96.34	80.24	70.95
6%	237.40	135.87	102.96	87.18	78.23
7%	243.89	142.38	109.79	94.39	85.81
8%	250.46	149.03	116.83	101.85	93.68
9%	257.09	155.82	124.06	109.55	101.81
10%	263.80	162.75	131.47	117.46	110.17
10.5%	267.18	166.26	135.25	121.49	114.43
11%	270.57	169.80	139.07	125.58	118.74
11.5%	273.98	173.38	142.92	129.70	123.10
12%	277.41	176.98	146.82	133.88	127.50
12.5%	280.85	180.62	150.76	138.10	131.94
13%	284.31	184.29	154.74	142.35	136.43
13.5%	287.79	187.99	158.76	146.65	140.95
14%	291.28	191.71	162.81	150.99	145.50
14.5%	294.79	195.47	166.90	155.36	150.08
15%	298.32	199.25	171.02	159.76	154.70
15.5%	301.85	203.06	175.17	164.20	159.34
16%	305.41	206.90	179.36	168.67	164.01
16.5%	308.98	210.77	183.57	173.16	168.71
17%	312.56	214.66	187.82	177.69	173.42
17.5%	316.16	218.57	192.10	182.24	178.16
18%	319.78	222.51	196.40	186.82	182.92
18.5%	323.41	226.48	200.73	191.42	187.69
19%	327.05	230.47	205.09	196.05	192.49
19.5%	330.71	234.49	209.47	200.69	197.30
20%	334.38	238.52	213.88	205.36	202.12
21%	341.77	246.67	222.77	214.74	211.80
22%	349.21	254.90	231.74	224.20	221.54
23%	356.70	263.21	240.79	233.72	231.31
24%	364.25	271.60	249.92	243.29	241.11
25%	371.85	280.07	259.12	252.92	250.95

Note: If payments are made more frequently, for example quarterly (four times per year), the total yearly figures may be slightly less than those shown in the table.

6.19 FOREST METRICS

(See also section 6.7.2, cord of wood, volume of timber).

STEMS PER ACRE TO STEMS PER HECTARE

Table A: 1 - 9 stems per acre

Stems per acre	1	2	3	4	5	6	7	8	9
	stems/ha								
	2.5	4.9	7.4	9.9	12.4	14.8	17.3	19.8	22.2

Table B: 10 - 1000 stems/acre ***Example: 540 s.p.a = 1334 stems/ha***

Stems per acre	0	10	20	30	40	50	60	70	80	90
	stems/ha									
0		25	49	74	99	124	148	173	198	222
100	247	272	297	321	346	371	395	420	445	470
200	494	519	544	568	593	618	643	667	692	717
300	741	766	791	815	840	865	890	914	939	964
400	988	1013	1038	1063	1087	1112	1137	1161	1186	1211
500	1236	1260	1285	1310	**1334**	1359	1384	1409	1433	1458
600	1483	1507	1532	1557	1582	1606	1631	1656	1680	1705
700	1730	1754	1779	1804	1829	1853	1878	1903	1927	1952
800	1977	2002	2026	2051	2076	2100	2125	2150	2175	2199
900	2224	2249	2273	2298	2323	2348	2372	2397	2422	2446
1000	2471									

IMPERIAL SPACINGS TO METRIC SPACINGS

Imperial Spacing	No. of Stems per acre	Nearest metric spacing	No. of stems per hectare	Operation
5 ft x 8 ft	1088	2.5 m x 1.5 m	2666	Establishment
9	968	2.5 x 1.5	2666	
10	872	3.0 x 1.5	2222	
11	793	3.5 x 1.5	1904	
12	726	3.5 x 1.5	1904	
13	670	4.0 x 1.5	1666	
14	622	4.5 x 1.5	1481	
6 ft x 6 ft	1210	2.0 m x 2.0 m	2500	
8	907	2.5 x 2.0	2000	
9	807	2.5 x 2.0	2000	
10	726	3.0 x 2.0	1666	
11	660	3.0 x 2.0	1666	
12	604	3.5 x 2.0	1428	
13	558	3.5 x 2.0	1428	
14	518	4.0 x 2.0	1250	
8 ft x 8 ft	680	2.5 m x 2.5 m	1600	
9	604	2.5 x 2.5	1600	
10	544	3.0 x 2.5	1333	
11	495	3.0 x 2.5	1333	
12	454	3.5 x 2.5	1142	
9 ft x 9 ft	538	2.7 m x 2.7 m	1371	Tending
10 x 10	436	3.0 x 3.0	1111	
11 x 11	360	3.4 x 3.4	865	
12 x 12	302	3.7 x 3.7	730	
13 x 13	258	4.0 x 4.0	625	
14 x 14	212	4.4 x 4.4	516	
15 x 15	194	4.5 x 4.5	493	
16 x 16	170	5.0 x 5.0	400	
17 x 17	151	5.1 x 5.1	384	
18 x 18	134	5.5 x 5.5	330	
19 x 19	120	6.0 x 6.0	278	
20 x 20	108	6.1 x 6.1	268	
21 x 21	99	6.5 x 6.5	237	
22 x 22	90	6.7 x 6.7	222	
23 x 23	82	7.0 x 7.0	204	
24 x 24	76	7.5 x 7.5	178	

Note: Establishment spacings are grouped to nearest 0.5 metre.
: Tending spacings are grouped to the nearest square measure (m^2)

CUBIC FEET PER ACRE TO CUBIC METRES PER HECTARE

Example: 9400 cu.ft/ac = 658 cu.m/ha

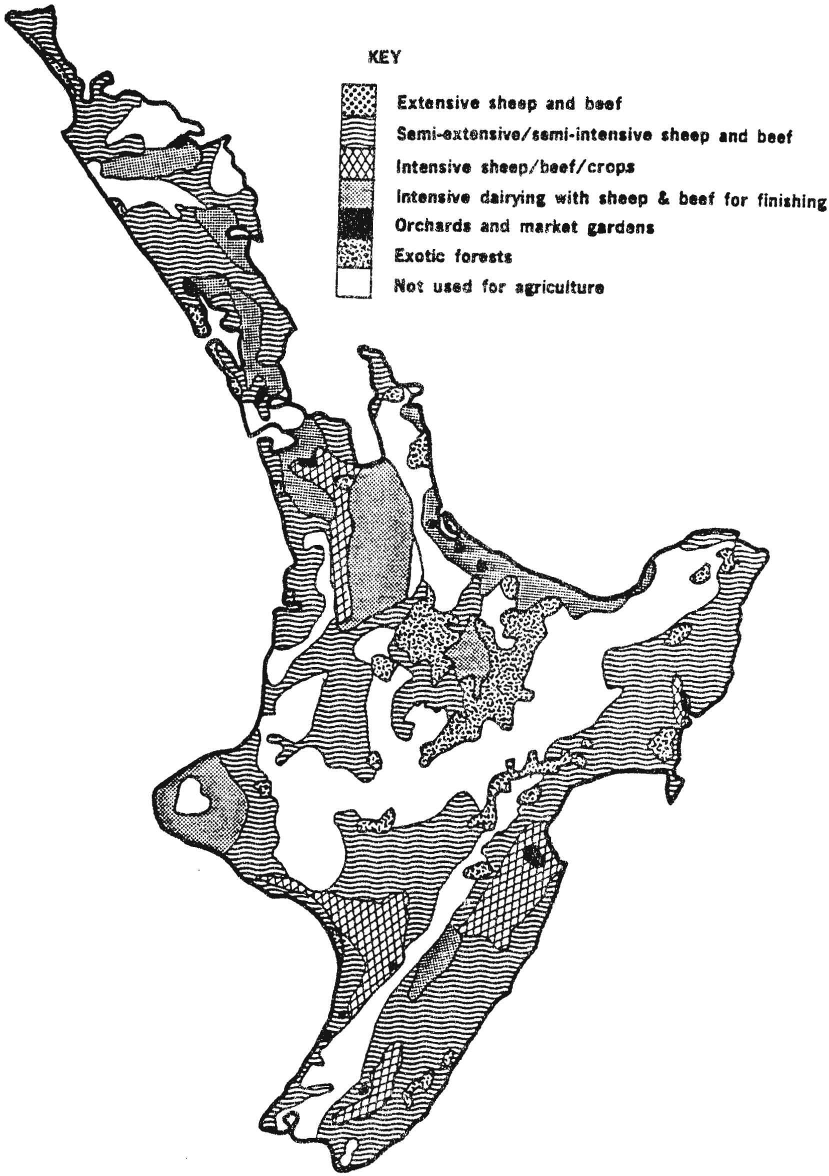
Cu.ft/ Acre	0	100	200	300	400	500	600	700	800	900
	Cubic metre(s)/hectare									
0		7	14	21	28	35	42	49	56	63
1000	70	77	84	91	98	105	112	119	126	133
2000	140	147	154	161	168	175	182	189	196	203
3000	210	217	224	231	238	245	252	259	266	273
4000	280	287	294	301	308	315	322	329	336	343
5000	350	357	364	371	378	385	392	399	406	413
6000	420	427	434	441	448	455	462	469	476	483
7000	490	497	504	511	518	525	532	539	546	553
8000	560	567	574	581	588	595	602	609	616	623
9000	630	637	644	651	**658**	665	672	679	686	693
10000	700	707	714	721	728	735	742	749	756	763
11000	770	777	784	791	798	805	812	819	826	833
12000	840	847	854	861	868	875	882	889	896	903
13000	910	917	924	931	938	945	952	959	966	973
14000	980	987	994	1001	1008	1015	1022	1029	1036	1043
15000	1050	1057	1064	1071	1078	1085	1092	1099	1106	1113
16000	1120	1127	1134	1141	1148	1155	1162	1169	1176	1183
17000	1190	1197	1204	1211	1218	1225	1232	1239	1246	1253
18000	1260	1267	1274	1281	1288	1295	1302	1309	1316	1323
19000	1330	1337	1344	1350	1357	1364	1371	1378	1385	1392
20000	1399									

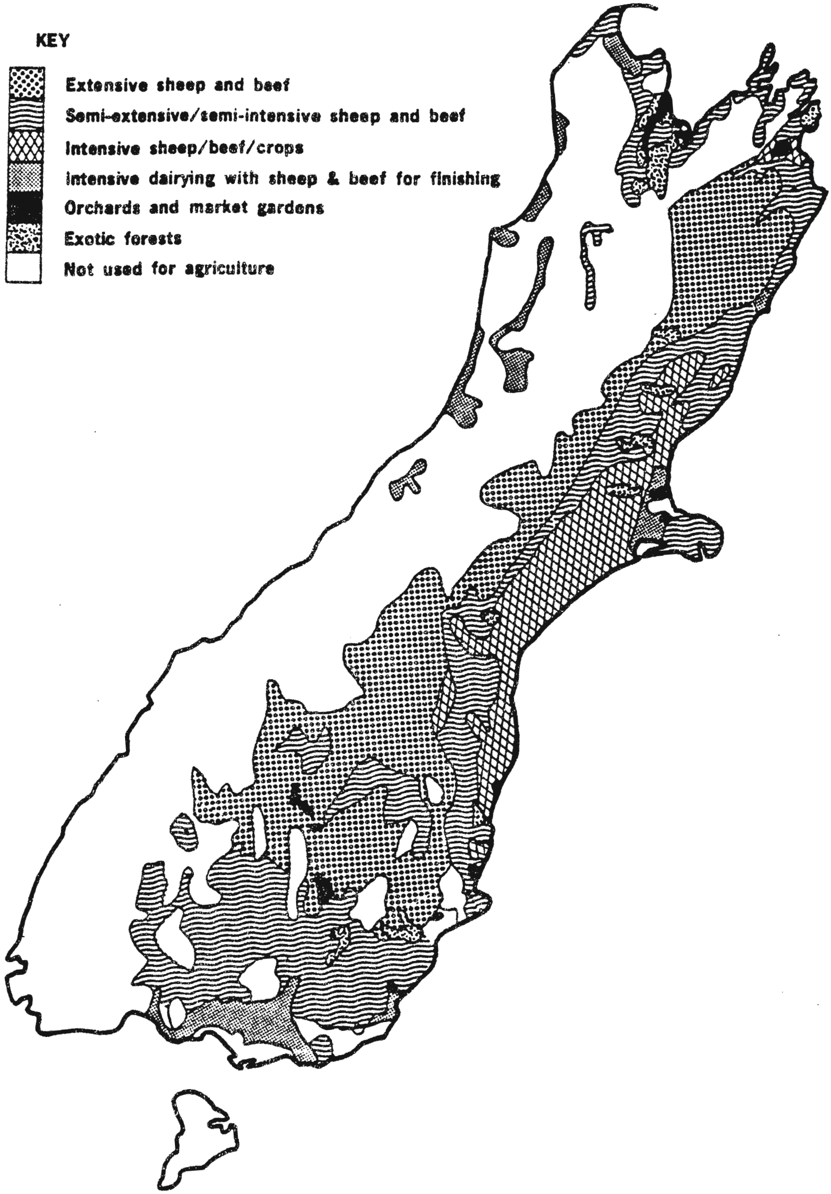
SECTION 7

NEW ZEALAND AGRICULTURE

7.1 LAND USE IN NEW ZEALAND

(Source: M.A.F. - Adapted from New Zealand Atlas, 1975).




KEY
Extensive sheep and beef
Semi-extensive/semi-intensive sheep and beef
Intensive sheep/beef/crops
Intensive dairying with sheep & beef for finishing
Orchards and market gardens
Exotic forests
Not used for agriculture

7.2 TYPES / CLASSES OF SHEEP AND BEEF FARMS IN NEW ZEALAND

The New Zealand Meat and Wool Board's Economic Service defines 8 distinct types or classes of N.Z. sheep and beef farms:

1. South Island High Country

   Extensive run country located at high altitude carrying fine wool sheep, with wool as the main source of revenue. Located mainly in Marlborough, Canterbury and Otago.

2. South Island Hill Country

   Mainly fine wool sheep with a carrying capacity of around three stock units per hectare. Wool and sales of cast-for-age ewes are a major source of revenue. Mainly in Canterbury.

3. North Island Hard Hill Country

   Carrying around eight stock units per hectare with twelve sheep per cattle beast. Sheep provide approximately three quarters of the revenue, the balance being derived from the sale of cattle. Mainly located on East and West coasts and the Central Plateau of the North Island.

4. North Island Hill Country

   Easier hill country and smaller holdings than class 3. Mainly Romney sheep and carrying over ten stock units per hectare with twelve sheep per cattle beast. A high proportion of stock sold is in forward store or prime condition. These farms are located throughout the North Island.

5. North Island Intensive Finishing Farms

   High producing grassland farms carrying twelve stock units per hectare with ten sheep per cattle beast. Replacement ewes are often bought in. Mainly located in South Auckland, West Coast North Island and Hawkes Bay.

6. South Island Finishing-Breeding Farms

   A more extensive type of finishing farm, generally breeding its own replacements and frequently with some cash cropping. Mainly in Canterbury and Otago.

7. South Island Intensive Finishing Farms

   High producing grassland farms carrying about thirteen stock units per hectare and with some cash crop. Mainly in Southland, South and West Otago.

8. South Island Mixed Finishing Farms

   Mainly in Canterbury with a high proportion of the revenue being derived from grain and small seeds as well as finishing stock.

7.3 PHYSICAL AND PRODUCTION/PERFORMANCE DATA OF NEW ZEALAND PASTORAL FARMS

7.3.1 Sheep and Beef Farm Data

(A) By Farm Type or Class:*

(see page G-5 for definitions)	1 S.I. High Country	2 S.I. Hill Country	3 N.I. Hard Hill Country	4 N.I. Hill Country	5 N.I. Intensive Finishing	6 S.I. Finishing Breeding	7 S.I. Intensive Finishing	8 S.I. Mixed Finishing
AREA								
Total Farm Area (ha)	9,860	1,870	760	420	210	380	180	260
Effective Area (ha)	9,860	1,790	630	380	200	360	180	260
STOCK UNITS (as at 1 July)								
Sheep	7220	4550	3910	2840	1780	2790	2200	1490
Cattle	1520	1170	1620	1070	660	270	65	80
Deer	50	20	15	15	15	5	10	0
Goat	10	10	10	5	10	10	5	0
Total Stock Units	8800	5750	5555	3930	2465	3075	2280	1570
STOCKING RATE								
Stock Units Per Ha	1.0	3.3	8.4	10.7	12.6	8.7	12.7	5.9
LABOUR UNITS	2.8	2.2	2.1	1.6	1.4	1.8	1.5	2.0
PERFORMANCE								
Lambing %	89	92	92	100	103	105	118	113
Calving %	80	81	78	83	84	85	90	-
PRODUCTION								
Wool Sold (Kg)	33900	20600	18800	15000	9200	13900	12600	7300
Meat Production(kg/ha)	7	30	85	130	180	105	180	81
Wool Production (kg/ha)	4	13	31	46	53	45	83	32

** Note: Figures are averages from 1982 to 1988 (figures rounded).*
Source: N.Z. Meat and Wool Board's Economic Service: The New Zealand Sheep and Beef Farm Survey.

(B) For <u>All Classes Average</u>* New Zealand Sheep and Beef Farms, 1979/80 to 1987/88:

Year :	1979-'80	'80-'81	'81-'82	'82-'83	'83-'84	'84-'85	'85-'86	'86-'87	'87-'88
Lambing Percentage	103.4	106.4	99.0	102.1	99.8	108.3	102.9	100.3	105.8
Calving Percentage	80.4	84.2	82.1	80.0	81.8	82.6	81.3	83.3	81.6
Wool Sold -									
: kg/sheep wintered	4.86	4.82	4.47	4.46	4.47	4.68	4.70	4.44	4.95
: kg/sheep s.u.	5.42	5.41	5.00	4.95	4.95	5.19	5.20	4.94	5.51
Sheep/Cattle Beast	17	18	18	20	22	20	20	19	18
Stock Units per									
Labour Unit -	1718	1813	1840	1856	1819	1890	1934	2042	2042
Fertiliser -									
:Total tonnes	63.7	53.3	52.5	45.1	48.2	53.4	26.1	29.3	28.9
:kg / eff. ha	126	105	105	91	99	110	54	60	58
:kg / s.u.	20.0	16.1	15.6	13.6	15.0	16.2	8.1	8.9	8.9

* *Figures are averages from eight farm classes/types (see pages G-5 and G-6).*
Note: figures are rounded.

Source: N.Z. Meat & Wool Economic Board's Economic Service: The New Zealand Sheep and Beef Farm Survey.

7.3.2 Dairy Farm Data

(A) ***By Farming Region (Factory Supply Farms):***

Table 1: Output Analysis*

Farming Region	Effective Farm Area (Ha)	Average Herd Size (Milkers)	Total Milkfat Production (kg)	Milkfat Per Cow (kg)	Milkfat Per Ha	Cows Per Hectare
Northland	79	149	20386	137	257	1.88
Central Auckland	64	139	19960	144	311	2.16
South Auckland	61	163	24814	153	409	2.68
Bay of Plenty	68	163	24712	152	368	2.42
Central Plateau	75	163	24679	151	330	2.19
Western Uplands	73	160	22839	143	313	2.19
Hawkes Bay	60	132	18776	142	314	2.21
Taranaki	60	147	23077	157	374	2.47
Wellington	62	145	21500	149	351	2.33
Wairarapa	67	149	21467	144	331	2.23
NORTH ISLAND	64	155	23293	150	364	2.42
Nelson/ Marlborough	68	139	20633	149	304	2.05
West Coast	82	140	19400	139	235	1.70
North Canterbury	76	171	24206	142	318	2.25
South Canterbury	72	165	24632	150	325	2.27
Otago	72	146	22458	154	314	2.04
Southland	62	110	17638	161	286	1.79
SOUTH ISLAND	74	142	20774	146	283	1.93
NEW ZEALAND	65	154	23102	150	357	2.38

* *Note: Figures are averages, taken from 1983 to 1989 data.*
: *'North Island', 'South Island' and 'New Zealand' figures are* ***weighted*** *averages.*

Source: Livestock improvement Division, New Zealand Dairy Board.

(B) ***Monthly Milkfat Production (Per Cow, By Region):***

Table 2 : Average Monthly Production of Milkfat Per Cow

Region*	KG MILKFAT PER COW											
	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
Northland..	22	22	22	20	18	17	15	14	12	12	15	19
Auckland..	23	23	24	22	20	19	17	16	14	13	17	20
B.O.P./ East Coast..	24	24	25	22	21	19	18	16	14	12	17	18
Taranaki..	23	24	22	23	21	20	18	16	14	12	13	15
Wellington/ Hawkes Bay	21	22	23	22	20	18	16	15	14	14	15	17
North Island	23	23	24	23	21	20	17	16	15	13	17	19
South Island	21	24	26	23	22	21	19	18	17	16	18	20
New Zealand	23	23	24	23	21	19	18	16	14	14	17	19

* Herd testing Region/Association

Note: Average figures for 1983/84, 1984/85, 1988/89.

: Statistics for May, June and July are based on far fewer cows than in other months. This is because only very few herds test in these months, and these are generally town milk supply.

Source: Livestock Improvement Division, New Zealand Dairy Board.

(C) ***Age Distribution Within An Average NZ Dairy Herd:***

	Age of Cow in Years								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Percentage in age group	24%	19%	15%	12%	9%	7%	5%	4%	5%
Average age is less than 5 years or 3 lactations.									

Source: NZDB Farm Production Report 1987/88

7.4 CLIMATIC DATA

7.4.1 Rainfall - Monthly and Yearly Averages for N.Z. Districts

Monthly Averages(1980-1989)
(measurements in mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average Yearly Total
Whangarei	99	133	131	98	112	146	144	176	146	108	97	102	1492
Hamilton (Ruakura)	101	67	93	86	84	119	96	100	83	96	83	101	1109
Te Puke	114	103	166	128	96	182	141	130	122	120	155	180	1637
Taumarunui	111	103	166	128	96	182	141	130	122	120	155	180	1637
Gisborne	46	61	107	99	89	119	129	86	88	49	68	55	996
Napier	31	47	100	62	65	63	84	56	69	44	56	67	744
Waipukurau	35	67	66	52	63	76	87	66	64	48	53	77	754
New Plymouth	108	104	128	119	129	130	157	117	126	148	112	140	1518
Palmerston North	69	70	86	61	85	88	91	83	74	80	82	78	952
Masterton	45	62	96	60	93	102	97	83	75	80	82	78	952
Blenheim	48	43	54	63	66	60	68	51	57	58	49	62	679
Nelson	86	56	87	94	87	94	78	62	83	81	89	84	981
Christchurch (Lincoln)	41	50	60	38	46	45	62	51	30	56	58	49	586
Methven (Highbank)	59	76	97	55	60	57	72	72	56	78	80	85	847
Ashburton	48	53	68	49	49	46	55	49	32	58	57	51	615
Hokitika	264	170	222	226	219	270	245	175	280	259	253	285	2868
Dunedin (Invermay)	81	68	73	55	78	85	77	50	51	72	57	79	826
Alexandra	49	36	43	27	27	34	26	24	21	27	30	42	386
Gore	128	92	89	70	108	74	74	67	66	74	84	96	1022
Invercargill	140	89	99	99	114	91	86	73	87	91	84	105	1158

References: *Meteorological Observations for Stations in N.Z, outlying islands and Antarctica. By N.Z Meteorological Service.*
N.Z Met. S. Misc. Pub. 109(1980,1981,1982,1983,1984,1985 & 1986)

Supplement to the N.Z Gazette: Monthly Climatological Tables
N.Z Met. S. Pub. 107(Mar 1987-Jan 1988)

N.Z Meteorological Service :Monthly Climate Tables
N.Z Met. Data Centre(Jan 1988-April 1990)

7.4.2 Evapotranspiration - Monthly and Yearly Averages for N.Z. Districts
(Source: N.Z. Meteorological Service)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Average	*Years Recorded*
Kaitaia	142	116	99	63	40	29	32	46	67	96	115	138	983	*'51 - '84*
Auckland	165	134	112	73	48	33	37	52	77	111	134	160	1136	*'62 - '84*
Thames	153	121	99	63	40	27	31	46	66	99	126	147	1018	*'59 - '80*
Hamilton (Ruakura)	130	104	83	48	26	17	20	33	53	82	106	125	827	*'41 - '84*
New Plymouth	146	119	94	62	41	30	33	45	66	93	115	142	986	*'73 - '84*
Gisborne	151	116	91	55	34	24	27	40	66	100	132	149	985	*'43 - '84*
Napier	151	116	93	56	34	21	24	38	64	99	128	146	970	*'41 - '84*
Palmerston North	134	109	86	50	27	17	20	34	55	83	108	128	851	*'41 - '84*
Levin	126	99	78	45	26	18	20	33	52	81	101	122	801	*'55 - '84*
Hokitika	108	83	65	35	18	12	15	29	45	71	92	110	683	*'65 - '84*
Nelson	148	111	85	43	19	10	11	25	52	86	117	139	846	*'43 - '84*
Blenheim (Grassmere)	176	138	114	73	46	30	33	50	79	119	150	167	1175	*'53 - '84*
Christchurch	149	111	83	45	24	13	17	31	56	94	126	147	896	*'53 - '84*
Methven (Highbank)	142	111	87	56	32	22	26	42	68	102	125	138	951	*'54 - '84*
Dunedin Airport	124	92	70	40	25	12	14	31	55	86	109	122	780	*'63 - '83*
Alexandra	134	101	74	32	12	4	6	19	47	83	112	133	757	*'42 - '82*
Gore	121	91	69	38	18	10	13	26	50	82	102	118	738	*'43 - '71*
Invercargill	123	92	68	39	23	15	16	29	53	86	109	126	779	*'51 - '84*

Figures are in millimetres

7.4.3 Weather Forecasting

Symbols

The following symbols are used for marking the positions of fronts and allied phenomena on charts. This is a monochromatic method of representation:

 Cold front at the surface*

 Warm front at the surface

 Occluded front at the surface

 Stationary front at the surface

* "At the surface" - intersection of the front with the surface, depicted by the chart.

 fog

 haze

 mist

 drizzle

 rain

 hail

 snow

 continuous

 precipitation

 thunderstorms

 lightning

 high pressure anticyclone

 low pressure - cyclone, depression

 various strength winds

 dew

 clear sky

 calm

 visibility, exceptional

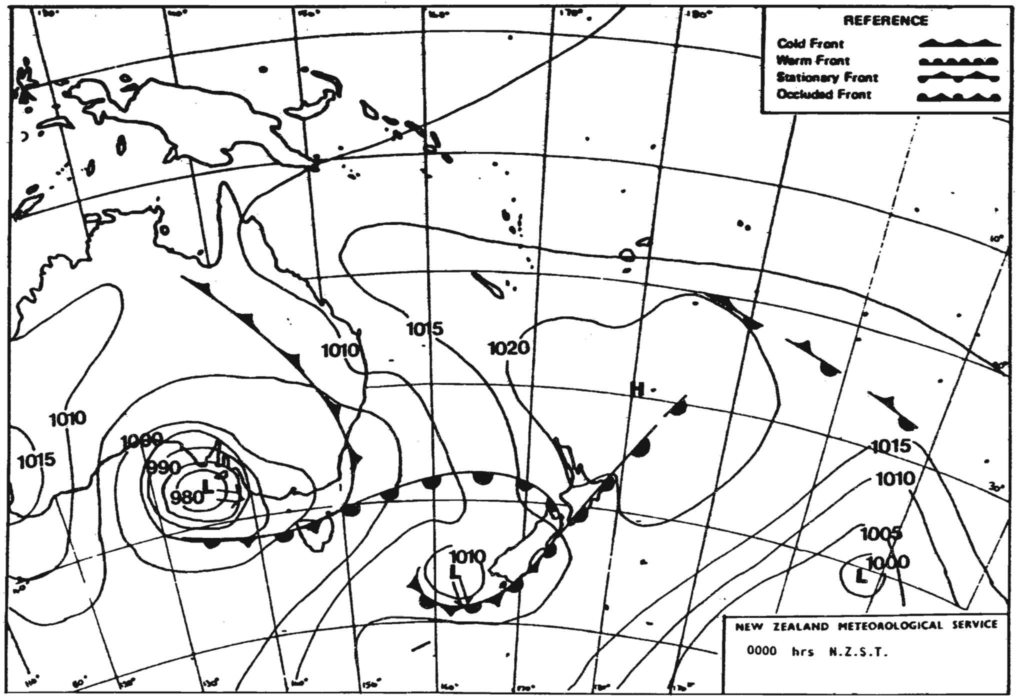
 cumulus cloud

 stratus

 alto stratus

 cirrus

Example of a Weather Map



Surface Charts

One of the important steps in the analysis consists of drawing isobars, lines along which the atmospheric pressure (corrected to sea-level) has the same value. On large area charts they are drawn at intervals of 5 millibars.

Meteorologists have discovered that the wind blows along isobars with a speed depending on how closely they are spaced. Isobars close together shows a strong wind, wide apart a light wind.

A westerly wind means lower pressure to the south, while an easterly wind means lower pressure to the north. Four important features:

1. Anticyclone

A region of high pressure. In New Zealand, wind blows in a counter-clockwise direction around an anticyclone. The central region is an area of light variable winds, usually accompanied by a spell of fine weather or cloudiness, scattered drizzle or fog. Normally moving from west to east.

2. Depressions & Fronts

A depression is a region of low pressure, a cyclone. The winds blow in a clockwise direction and are often strong. In New Zealand regional depressions generally move towards the southeast or east. Rain is usually concentrated in quite distinct parts of a depression. Many depressions are composed of two distinct airmasses, one warm and the other cold. The boundaries between these are fronts. A line along which warm air is advancing and displacing cold air is a warm front, and vice-versa. Most of the cloud and precipitation in a depression is concentrated on the fronts. Their passage is often marked by a clearance or change in weather and wind direction. Often a deep depression, a cold front, may overtake a warm front forming a single front called an occlusion.

3. Troughs of Low Pressure

Sometimes an area of low pressure in an elongated form extends across the chart as a narrow region, along which atmospheric pressure is lower than directly on either side. This is known as a trough of lower pressure. It often extends from the southeast towards the northwest. As the depression passes south of New Zealand the trough moves from the southwest to northeast across the country. An anticyclone is usually located on either side of the trough. Within the trough, there is often a cold front, preceded by northwest winds and a belt of cloud and rain, followed by southwest winds, lower temperatures and showers.

4. Ridges of High Pressure

Between two depressions or troughs of low pressure, there is often a ridge of high pressure. An elongated area, the same as the trough, except that atmospheric pressure is higher than in the immediate vicinity on either side. This is generally accompanied by a brief period of fine weather similar to an anticyclone.

Prognostic Charts and Forecasting

Analysis of the current weather situation is a necessary prerequisite to forecasting. The first step is the construction of a "progrostic chart" for 24 hours after the latest analysis. The future locations of anticyclones, depressions, troughs, ridges and fronts are decided by the meteorologist from weather pattern trends over the last few hours and days. Locations of "jetstreams" (ribbons of very strong wind at altitudes of 9-12 km), temperature changes, land masses and cold or warm oceans are also noted. Atmospheric conditions are very complicated and weather forecasting can never be simple. Patterns of flow, fronts and their associated weather are always changing.

Topography has a strong influence resulting in cloud and heavier rain on the windward wide of mountain ranges, and dry weather on the lee-side.

An over-estimate of cloud or wind at night, may lead to fog or frost being omitted from the forecast.

Reference: *N.Z. Meteorological Service, Misc. Pub. 138.*

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