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Chapter 1

Limitations to pasture production and choice of species

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INTRODUCTION

The South Island hill and high country is defined as those areas which were in natural grassland at the time of early European settlement. This includes the major geographical regions of dry hill and high country of Marlborough, Canterbury and North Otago, and the wet acid tussock grasslands of Otago and Southland.

To define the most appropriate pasture species for farming in these areas, it is first necessary to define the appropriate environmental factors since they largely determine the types of farming systems possible. Once this has been done, it will be found that there are only one or two pasture species which are the best option in each environment or farming system.

This region of the first large scale agricultural colonisation in New Zealand supported tussock grasslands. The environment was too cold and/or dry to support shrub or forest vegetation as elsewhere. These native grasslands have been modified in order to get a usable output, just as forests were degraded to grass in other regions of New Zealand for this purpose.

The high country being a natural grassland zone can be farmed at the low fertility state as well as at the various stages through to high fertility. As a consequence, the range of pasture species options for the South Island hill and high country is larger than for other farming regions. Where pastures are ex scrub or forest land, it may not be possible to farm at low or moderate fertility levels because of re-invasion by scrub species.

THE HILL AND HIGH COUNTRY ENVIRONMENT

The most important environmental factors influencing farming and the choice of pasture species in the hill and high country of the South Island are temperature, soil moisture, soil fertility and pasture management.

Temperature and moisture gradients define the general pattern of soils, original vegetation and present farming systems within New Zealand (Fig. 1. lj. The rapid decline in pasture productivity with decreases in both moisture and temperature means that pasture yields in the high country will generally be much lower than in other regions, and explains why farms and paddocks need to be much larger to carry a given number of stock.

Temperature

Temperatures vary with season, altitude, latitude, aspect and slope. The annual variation in mean monthly temperature at a site is about 10°C; with a further variation of some 8°C for altitude, slope and aspect. While temperature is a factor which cannot be modified, it has to be recognised as fundamental in determining the farming pattern and choice of species.

The high country is on the coldest margin of New Zealand agriculture for both mean and seasonal temperatures, and for variation with altitude, aspect and slope. Thus even the lower altitude inland basins have a 4-5 month non-growth period and a potential for frosts in all seasons.

Soil moisture

The South Island hill and high country covers the whole range of soil moisture conditions. Consequently a wide variation in pasture species is required, ranging from those that can survive extreme drought on the dry inland basins and hills, to those that can survive the wet conditions of high altitude or alpine gorge runs.

Fig. 1.2 shows this interaction of temperature and moisture in determining first, the annual production from high in the warm-wet to low in the

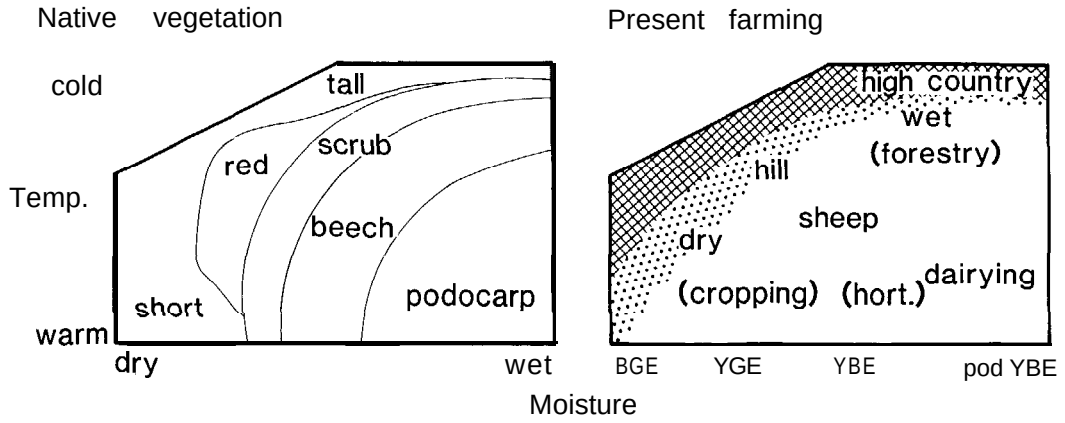

Figure 1.1 Distribution of original vegetation and present farming in relation to the environmental gradients of temperature and moisture. The high country is indicated by cross hatching and the hill country by dots.

cold and/or dry and second, the seasonal distribution of this yield with no winter growth in the cold and reduced summer growth in the dry.

Soil fertility

For a given site, the response to improved fertility is about a five fold increase in pasture production compared with the native state. The major impact of fertility is such that it often become the main criterion for selecting pasture species. Fig. 1.3 shows potential pasture yields in relation to temperature and moisture in three different fertility regimes.

Pastoral development in hill and high country relies on successful establishment growth and nitrogen input of legumes. This requires correction of deficiencies of phosphorus, sulphur and sometimes lime. The geographical pattern of fertiliser need is related to climate and soil type.

In general terms there is a greater need for sulphur than for phosphorus for pasture establishment on the brown-grey and yellow-grey soils of the dry inland areas such as the McKenzie Basin. Requirements for phosphorus increase with increasing rainfall and leaching of nutrients, so that quantities needed for pasture development are greatest on the yellow-brown soils of the higher and wetter country (Table 1.1). Soil tests should **be** used to confirm these recommendations. Maintenance requirements on each of these soil types (Table 1.1) assume a carrying capacity of at least 4 stock units/ha. A different approach to maintenance rates which allows for the differences in production, utilization and stocking rate on contrasting soil

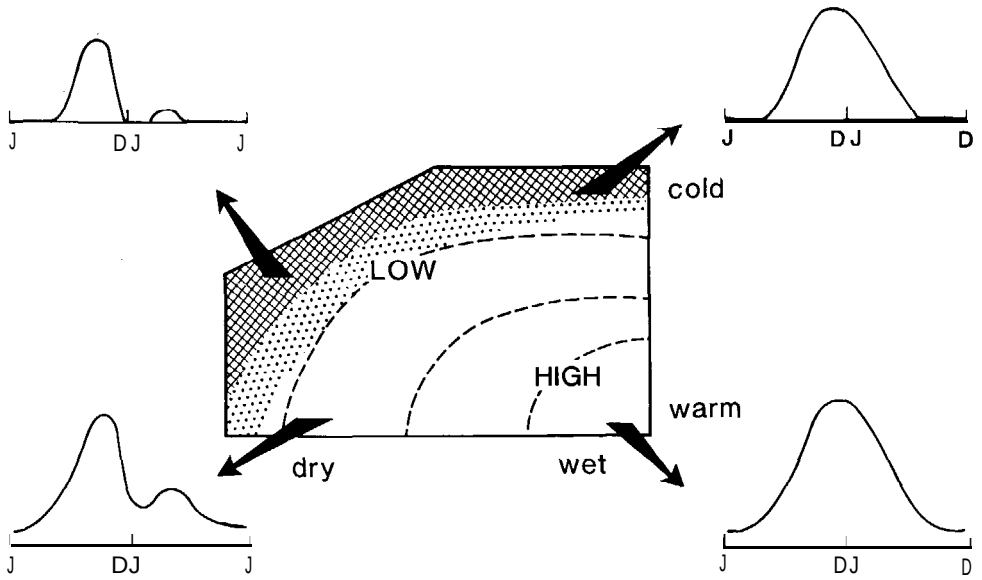

Figure 1.2 Variation in annual yields and seasonal growth patterns with temperature and moisture.

Table 1.1 Initial and maintenance fertiliser rates for South Island hill and high country.

Soil	Establishment	Maintenance'
Dry — brown grey & yellow-grey soils	200 kg/ha Mo sulphur super (0:7:0:27)[2,3]	200 kg/ha sulphur super (0:7:0:27) every 2 or 3 years
Moist — yellow brown	250 kg/ha Mo superphosphate (0:9:0:9)	125 kg/ha superphosphate annually

1. Molybdenised fertiliser used every 4-6 years.
2. May be replaced by 100 kg/ha elemental sulphur where soil P test above 20.
3. (N:P:K:S)

types, is to allow 25 kg superphosphate per ha year for each stock unit.

ROLE OF DIFFERENT PASTURE SPECIES

Besides these three environmental factors the suitability of a pasture species for a particular site is determined by pasture management. Indeed pasture production is usually determined more by these four factors, than by species or cultivar variation.

Given the three, environmental variables of temperature, moisture and soil fertility it is possible to make a reasonable estimate of the potential pasture production (Fig. 1.3). All pasture species will tend to follow this pattern in that all will be most productive under warm, moist, high fertility conditions. For instance browntop, if given these conditions can produce similarly to ryegrass. However only one or two species reach the full growth potential of a site for the particular combination of temperature, moisture and fertility.

Fig. 1.4 attempts to place a range of pasture species in their most suitable environment in relation to temperature, moisture, fertility and management though it is realised there is a large overlap between species in their suitability. We re-emphasise that this does not indicate where each species grows best, but rather where each grows better than others that could be grown in those conditions. Similar information is given in Table 1.2 and 1.3 of the relative response and tolerance of species to grazing management and other factors.

For the high country there will be an obvious preference for species which grow better at lower temperature. Few detailed studies have been conducted but grasses are generally superior to legumes. For example, temperatures are generally too low for adequate or reliable subterranean clover growth in the high country.

Lower temperatures also mean higher frequency of frost, which in the high country can occur throughout the year, though naturally more often in the winter. Hence frost tolerance is an important characteristic of pasture species, with the grasses generally being more tolerant than legumes. However both legumes and grasses are vulnerable at the seedling stage, because they are in the more intense frost zone close to the ground. For mature stands of grasses and legumes, there is a large interaction between pasture bulk, species and susceptibility of foliage to frost damage. White clover is the legume most susceptible to foliage frosting, followed by lucerne, lotus and alsike clover, with tetreploid red clover being the least susceptible. For mature grasses

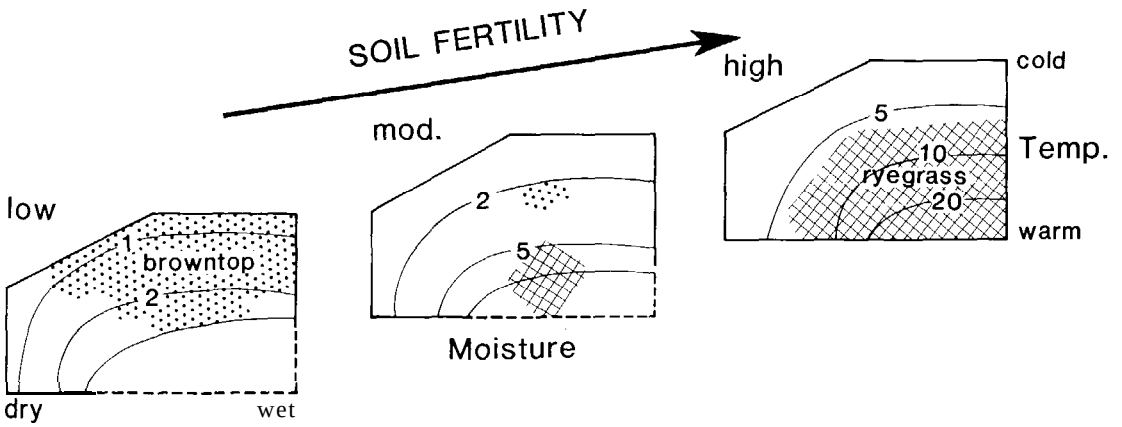

Figure 1.3 Estimated annual yields (tonne DM/ha/year) in relation to temperature, moisture and soil fertility, together with the best zone for two grasses, browntop and perennial ryegrass.

Table 1.2 Environmental suitability of pasture species for South Island hill and high country.

Species	Temp.	Moisture				Fertility			Grazing	Accept-ability	Seed rate	Avail-ability
		a	b	c	d	a	b	c				
a) LEGUMES												
Alsike clover	l-2	2	2	2-3		2	2-3	2	2	2	2-4	4
White clover	2-3	l-2	l-2	3	223	1	2-3	2	1	3	2-4	4
Red clover	1-2	l-2	l-2	3	2-3	1	2-3	l-2	3	3	2-4	4
Lucerne	2-3	3	3	3	1	1	3	1	3	3	4-10	4
Lotus	l-2	1	1	1	2-3	2	l-2	3	2	2	5-10	4
Birdsfoot trefoil	2-3	2-3	3	2	1	2	l-2	2	3	2	5-10	3
Suckling clover	1	1	1	1	2-3	3	1	3	1	2	½-1	1
Haresfoot clover	2	3	2	1	1	3	1	1	1	1	0	1
Zig-zag clover	2	2	2	1	2-3	3	1-2	2	1	2	l-2	2
Caucasian clover	l-2	2	2	1	2	3	1-2	2	1	3	1-2	2
Crown vetch	2-3	3	3	1	1	3	1-2	1	1	2	1-2	2
Yellow sweet clover	l-2	2	2	1	2	2	l-2	2	2	2	2-5	2
Subterranean clover	3	2-3	3	1	1-2	1	3		2		5-10	2
Vetch or tares	3	2-3	3	1	1	2	2	1	3	2	5-15	2
Hairy canary clover	2	3	3	1	1	3	l-2	1	2	1	4	2
Prostrate canary clover	2	3	3	1	1	3	l-2	1	2	1-2	4	2
Russell lupin	2	2	2	1	2	2	2	1	2	2	2-5	3
Greenfeed lupin	2	2	2	1	2	1	3	2	3	3	5-10	3
b) GRASSES												
Cocksfoot	1	2-3	2-3	2	l-2	2	1-2	2	2	3	5-15	4
Tall fescue	1	2	2	3	2-3	l-2	2-3	1	2	3	5-15	3
Perennial ryegrass	2-3	1-2	l-2	3	2-3	l-2	2-3	1	1	3	10-15	4
Hybrid ryegrass	2-3	1-2	1-2	3	2-3	l-2	2-3	1	2	3	IO-15	4
Timothy	2	1	1	3	3	l-2	3	2	3	3	2-5	4
Browntop	l-2	2	2-3	1	1-2	2-3	1	3	1	2	¼ -2	4
Sweet vernal	1-2	2	2-3	1	1-2	2	1	2	1	2	0	1
Yorkshire fog	2	1-2	2	1	2	2	1	3	2	3	2-5	3
Fescue or hard-tussock	1	3	3	na	1	3	1	2	2	1	0	1
Blue tussock	1	2	3	na	2	3	1	2	2	2	0	1
Silver tussock	1	2	2	na	2	2	2	2	2	1	0	1
Snow tussock	1	2	2	na	2-3	3	1	3	2	1	0	1
Red tussock	1	1	1	na	3	3	1	3	2	1	0	1
Danthonia	2-3	3	na	1	3	1	1	1	1	1	0	1
Phalaris	2-3	2	1-2	l-2	2-3	3	1	2	3	l-3	3	
Crested dogstail	3		1	2		l-2	2	1	1	2	5	4
Annual ryegrass	2	4	1	3	223	1	3	1	2	3	15-25	4
Prairie grass	3	2	2		l-2	1	3	1	3	3	20-30	
Smooth brome	2	2	3	l-2	2-3	2	2	1	1	3	5-15	4
Mountain brome	2	2	2	l-2	2-3	l-2	3	1	3	3	20-30	2
Chewings fescue	2	3	3	1	2		1	3	1	1	l-4	1
Kentucky bluegrass	2	2-3	3	1	2	233	1	1	1	1	0	1
Tall oat grass	2	3	3	1	l-2	3	1	1	3	2	1-3	2
Pubescent wheatgrass	3	3	3	1	2	3	1	1	2	2	l-3	2
c) HERBS												
Sheep sorrel	1	2	3	na	1	3	1	3	1	1	0	1
Yarrow	2	3	2	na	1	2	2	2	2	2	2-10	2
Catsear	1	2	2	na	2	3	2	2	1	2	0	1
Mouse-ear hawkweed	2	2-3	2	na	1-2	2	1	1	1	2	0	1
King devil	2	2-3	2	na	1-2	3	1	2	2	2	0	1
Dandelion	2	2	2	na	2	3	2	2	1	2	0	1
Sheeps burnet	2	2-3	3	na	1	2	1	1	2	2	10-15	3
Chicory	3	2	2	na	2	1	3	1	3	3	2-5	2
d) SHRUBS												
Matagouri	1	3	2	na	1-2	3	1	3	1	1	0	1
Briar	2	2	3	na	1-2	2	1	2	1	0	1	1
Gorse	2	2	1	na	2	2	2	3	1	1	0	1
Broom	2	2	2	na	2	2	1	3	1	1	0	1
Tree lupin	3	2	1	1?	2	2	1	2	2	1	5-15	3
Tagasaste or tree lucerne	3	2	1	2?	1-2	1-2	2	1	3	2	2-5	3
Tree medick	3	3	1	13	1	2	1	1	3	2	5	2
Saltbush	3	3	1	1	1	2	1	1	3	2	10	2
Mountain mahogany	3	3	1	1	1	2	1	1	2	1	10	2
Bluebush	3	3	1	1	1	2	1	1	3	2	10	2

Key to Table 1.2 Environmental suitability of pasture species for South Island hill and high country.

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. Medium
3. High
(c) Suitability for intensive irrigated pastures
1. Low
2. Medium
3. High
(d) Value in livestock feeding systems
1. Low
2. Medium
3. High

Availability of seed (1985)
1. Would not be sown
2. Only available in experimental quantities
3. Limited quantities available
4. Freely available

Soil fertility
(a) Suitability for low fertility
1. Low adaptation to low soil fertility
2. Moderate
3. High
(b) Sites where species is of greatest value
1. Low fertility
2. Medium fertility
3. High fertility
(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
(Inoculated/coated in case of legumes)

the most frost tolerant are tall fescue, prairie grass and cocksfoot, followed by ryegrasses, timothy, bromes and phalaris. Complete winter kill of plants is not common, though it occurs for white clover and ryegrass in some years.

Because of the winter no-growth period, there is a need for saved in-situ feed with a consequent demand for species with good autumn growth, good palatability in the rank stage and slow loss of feed quality following frostings. Species differ in these characteristics. For example, cocksfoot has good autumn growth and frost tolerance but lower acceptability to stock, whereas perennial ryegrass has moderate autumn growth and high acceptability to stock, but lower frost tolerance.

Legumes are of prime importance in this region due to the naturally low soil nitrogen status. Next to improved pasture management through subdivision, legumes are the principal means to development of hill and high country. Pastures remain legume dominant for many years. While grasses should ultimately be more important because of their greater winter feeding quality and cold tolerance, their establishment is initially problematical. They can be sown successfully in the fully cultivated situation, but their early establishment from aerial oversowings of large blocks leaves a lot to be desired. Generally a better response is gained initally from the stimulus of resident native or adventive species, rather than sown grass species.

Species and cultivars must be selected according to their likely use (and abuse) as well as their environmental suitability. Hill and high country properties are commonly run as large, set stocked paddocks. This should be regarded as an accident of history rather than a desirable situation. The need for improved grazing management through subdivision is as great or greater in the marginal environments of the hill and high country as elsewhere in New Zealand. When pastures are utilised during the growing season, grazing management must take into consideration the differences in species tolerances of grazing intensity and duration, and regrowth interval. The most marked distinction is between plants that are tolerant of close grazing/set stocking and those requiring lax grazing or long regrowth periods (Table 1.2).

The farmers in the hill and high country, like those elsewhere have to reach a compromise between three general restraints: 1. the feeding requirements of the particular type of animals they choose to farm, 2. the type of land within their particular farm boundary and 3. the suitability of the different pasture species for those different land classes. Temperature and moisture are characteristics of each site and cannot be changed except for the special case

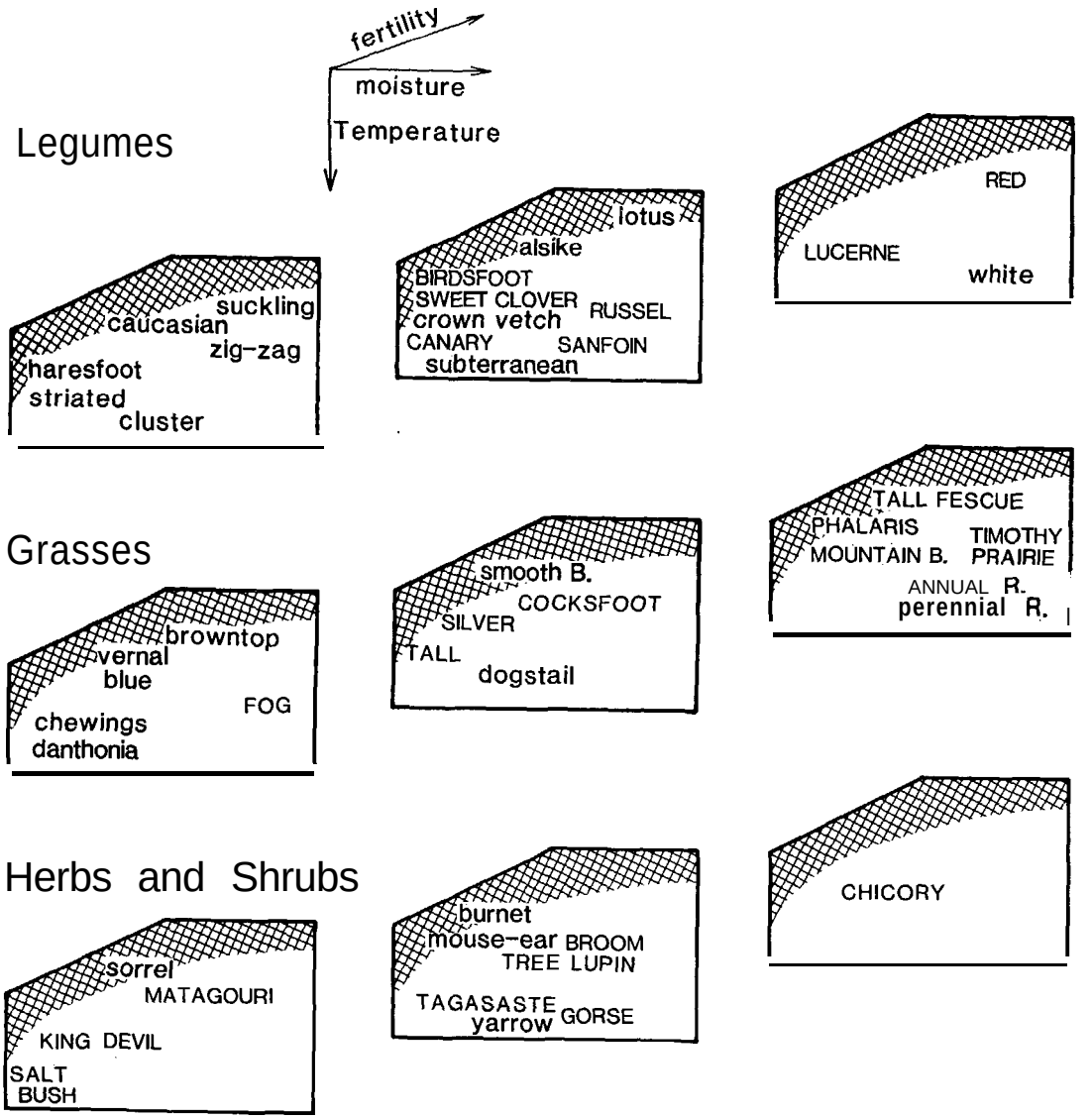

Figure 1.4 The most suitable role of some pasture species in relation to the environmental factors of temperature, soil moisture, and soil fertility. Names of species more suited to lax grazing are given in capital letters.

of irrigation. Thus, major changes in farm productivity depend on improvements in soil fertility and pasture management to enhance the growth, utilization and persistence of resident and introduced pasture species.

SUMMARY

1. The most appropriate species for any pasture is determined by the four environmental factors of temperature, soil moisture, soil fertility, and pasture management.
2. 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. The suitability of pasture species for the various conditions and the most suitable farm management role for species and cultivars in this region are listed in Tables 1.2. and 1.3.
3. Legumes are required for growing season nitrogen fixation, and grasses for winter cold tolerances.

Table 1.3 Most suitable farm management role for species and cultivars in South Island hill and high country. Species and cultivars arranged in approximate preferred order within each group.

AUTUMN SAVED STANDING WINTER FEED

Low to moderate soil fertility

Grasses >legumes

Cocksfoot; browntop; sweet vernal; tall oat grass

Alsike; crown vetch

High soil fertility

Grasses legumes

Tall fescue (Syn II >Roa = S170);

cocksfoot (Kara = Wana >Saborto = Apanui); perennial ryegrass; prairie grass; phalaris.

Red clover (Pawera >Hamua = Turoa); alsike; lotus (Maku) (white clover, lucerne and birdsfoot seldom suitable in this role past May).

SPECIAL PURPOSE WINTER CROPS

Moderate soil fertility

Ryecorn (Rapaki) >oats (Omihi, Saia)

High soil fertility

Annual ryegrass (Tama >Manawa = Paroa >Moata); barley (Claremont)

Turnip; swede; kale; green feed lupin

LATE WINTER/EARLY SPRING SPECIAL PURPOSE FEED

Ryecorn, annual ryegrass

Lucerne, for high soil fertility (but would need subsequent long resting); sheeps burnet — (for low to medium soil fertility).

Subterranean clover and tares — lowest altitude warm country.

SPRING/EARLY SUMMER

Low soil fertility

Haresfoot clover; suckling clover; red clover; Caucasian clover (Monaro >Prairie >Treeline > Alpine); zig zag clover.

Browntop; sweet vernal; chewings fescue; blue tussock; timothy; Yorkshire fog; native tussocks; danthonia; pubescent wheat grass; sheep sorrel.

Moderate soil fertility

Alsike clover (Iso 4N >Dawn = Aurora >NZ and Canadian uncert. >Tetra); sweetclover (Yukon Norgold >Denta >Polara = Arctic) short term; birdsfoot trefoil; Russell lupin — moderate to moist soil; lotus (Maku) — moist acid soil; crown vetch (Emerald = Chemung >Penngift); subterranean clover (Mt Barker = Woogenellup >others)

Cocksfoot (Wana >Saborto = Apanui); smooth brome; Yorkshire fog (Massey Basyn); crested dogstail; silver tussock.

SPRING/EARLY SUMMER Continued

High soil fertility

Alsike clover (Iso 4N >Dawn = Aurora >uncert. > Tetra); lucerne (WL318 >WL311 >Deseret = Wairoa); white clover (Huia Pitau); red clover (Pawera >Hamua >Turoa).

Cocksfoot (Wana Saborto = Apanui); perennial ryegrass (Nui = Ellets = Ruanui); tall fescue (Roa = S170); phalaris (Maru); hybrid ryegrass (Ariki >Manawa); mountain brome; prairie grass (Matua).

LATE SUMMER/AUTUMN

Low soil fertility

Suckling clover

Chewing fescue; blue tussock; native tussocks; danthonia; sheep sorrel; yarrow.

High soil fertility

Lucerne; red clover; white clover (Huia >Pitau)

Tall fescue (Roa = S170); perennial ryegrass; mountain brome; prairie grass.

HAY OR SILAGE — DRYLAND

Moderate to high fertility

Lucerne (Deserte = WL318 >Wairau > Saranac = Washoe); red clover (Pawera > Hamua >Turoa); alsike clover (Iso 4N >Auroa = Dawn >uncert.) and possibly birdsfoot.

Timothy (Kahu); cocksfoot (Kara >Saborto >Wana = Apanui); tall fescue (Roa = S170); phalaris (Maru).

SHRUBS FOR RESERVE FEED

Low to moderate fertility

Tagasaste; briar; tree lupin; tree medic; saltbush; bluebush; mountain mahogany.

SPECIAL PURPOSE LAMB FATTENING FEED

High soil fertility

Red clover (Pawera >Hamua >Turoa); white clover (Huia); Mountain brome; prairie grass; hybrid ryegrass (Manawa = Ariki).

FURTHER READING

Scott D. 1979. Potential pasture production in hill and high country. *Proceedings of the 1979 Hill & High Country Seminar, Lincoln College.*

Scott D., Keoghan J.M., Cossens G.G., Maunsell L.A., Floate M.J.S., Wills B.J., Douglas G. 1985. Pasture species for the South Island hill and high country. *MAF Bulletin (in* press).