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Edited by

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D. H. Crabb
Recognition of Professor Sir James Stewart.

Professor Sir James Stewart retires as Principal of Lincoln College in December 1983. Mr Acland made a presentation to Sir James on behalf of all farmers on this, the last occasion he attended the conference in that capacity.

On behalf of us all at the Farmers' Conference, I would like to thank you Jim for all you have contributed to this conference. I feel that your greatest contribution has been to make Lincoln College and farmers vital to each other.

Isolating themselves can be easy for academics, but Jim has made sure that this does not happen at Lincoln College. He has brought together the two sides of farming: theoretical and practical.

Farmers like coming to Lincoln. This can be seen by the numbers at this conference.

New Zealand agriculture is having a difficult time just now, but there is still a lot going for the farmers of this country. Providing that we are given the right economic climate in which to work, and providing people like Jim Stewart come forward to lead us, then we farmers have tremendous opportunities and challenges ahead of us.

J.O. Acland,
Past chairman, Lincoln College Farmers' Conference Committee
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Introduction

Professor Sir James Stewart, Principal, Lincoln College.

It is now more than 20 years since the Department of Farm Management and Rural Valuation at Lincoln College carried out a detailed survey of irrigated farms in the Ashburton-Lyndhurst Scheme, comparing productivity and profitability with a comparable group of dryland farms in the same region.

Detailed physical and financial results for the previous three years were analysed; results established that irrigated farms, in spite of producing significantly more, and generating more employment of resources both on-farm and off-farm, nevertheless, were making no greater profits than the dryland farms.

The report caused considerable dismay to the strong proponents of irrigation development, was also of some surprise and concern to me, but was an accurate and honest reflection of the facts at that time.

Further study concentrated on reasons for the wide variation in the performance of individual irrigated farms. Clearly demonstrated was that on those farms where there had been a major change of the farming system to ensure the water resource was fully and productively used, profitability was relatively high, compared to those farms on which irrigation was being used merely as an insurance in traditional dryland farming.
Hopefully, these results made a small contribution to the recognition of the need to develop appropriate management systems if irrigation was going to be made to pay. Tomorrow we are going to hear from a number of outstanding irrigation farmers, giving examples of management systems which have led to very high physical and financial performance.

I must refer also to two other important factors which have occurred since the completion of that report.

First, the development of efficient automatic border-dyke irrigation, led by Winchmore, and more recently, the evolution of travelling spray irrigators, which have been the main factors in reducing the labour requirement of irrigation farming.

Second, we seem to have reached a technical barrier in our dryland farming techniques, particularly, on lighter soils. Great progress was made during the 1960s and early 1970s as we learnt more about the productivity and management of lucerne, and as we developed sheep management techniques compatible with this remarkably versatile plant. But, in recent years, the failure of much lucerne because of aphid attack and inappropriate management has led to a lessening of confidence in it. I am sure this will be reversed, but this, together with the ravages of a lengthy abnormally-dry period has led to considerable retrenchment of our dryland farming.

This is not to say that there still isn’t considerable scope for general improvement in dryland farming in Canterbury and similar regions, but on properties at the forefront of this development, such as Ashley Dene, real progress in improving productivity has not been made for some time. We are depending now on slower-response technology, such as improving the reproductive and growth-rate performance of sheep.

If we were to depend now on further technical innovation only in our dryland farming methods there would be only very slow progress. There is a great deal to be done in animal nutrition and growth, disease control, soil fertility, pasture science, pest, diseases and weed control, agricultural engineering, and farm management. If agriculture and horticulture are to provide the underpinning of further economic and social development, or perhaps more accurately, to arrest the decline, our water resources will have to be used with a great deal of imagination and vigour.

Comprehensive and rigorous cost benefit analysis is essential for appraisal of irrigation schemes, which involve the investment of public money. Those who have been involved, however, will acknowledge there are intractable problems, and one is the ability to take into account fully the so-called external benefits. There has been some useful work of this kind, such as that on the lower Waitaki Scheme, which pointed to substantial secondary benefits. Full assessment of ripple effects of land development, throughout the whole community will always pose problems.

Another benefit not able to be measured adequately, is the increase in the versatility of future land use resulting from the provision of irrigation. For example, although the technical feasibility of dairying under border-dyke irrigation was established by Winchmore many years ago, only now, partly as a result of shifts in the pattern of land use in the North Island, and of sharp changes in the relative profitability of dairying and sheep, has widespread interest in dairying on border-dykes emerged.

Perhaps even more striking, as a result of the tremendous skills demon-
strained by leading arable farmers under both border-dyke and spray irrigation, has been the demonstration of highly-profitable and flexible, intensive-cropping systems.

It is highly probable that the cost-benefit studies of irrigation development, and other forms of land-use intensification, rarely embrace the full extent of the benefits.

Therefore, evaluating other water uses with the same degree of rigour is necessary. I must concede, as a very sporadic salmon fisherman (once in the last two years), that I have always been somewhat puzzled by the method usually adopted in putting a value on salmon fishing. Generally, the method used has been to assess the costs which salmon fishermen are prepared to meet, and then assume this is the value to be placed on the fishing.

However, some measurability is needed. Also to be kept in mind is that salmon have been here for even less time than Pakehas; just to get this in the right perspective.

I now wish to say something about one particular assertion I have seen in the context of the great debate over the use of the Rakaia River waters: this is that there is no justification for abstraction of water "merely to make a lot of well-off farmers better off".

If we really wanted well-off farmers on the plains of Canterbury, capable of withstanding periodic recessions, cost inflation, and droughts, the best way would be to have far fewer farmers, each on large holdings of 5000 ha to 10,000 ha, running two or three stock units a hectare, or growing 2 t of wheat with very low-level inputs and low capitalization.

Then we would be exactly like a certain South American republic with which I am familiar. We would have many less farmers, they would live in stately homes on their holdings, and they would maintain other homes in Christchurch, from where they would commute to their farms only to supervise the work. There would be a serving class of farm workers and domestic servants.

Rural services and rural townships would be primitive, and there would be no vigorous rural community life. Neither would there be many jobs generated by agriculture beyond the farm gate. Sometimes I have bad dreams about the potential decline of the New Zealand economy and society towards this situation, if agriculture is ever allowed to go into decline, or if land and water resources are not used with responsibility and imagination.

If, on the other hand, we want more jobs in processing, servicing, contracting, marketing, transport, professional firms, retailing, research and extension; if we want regional development for social objectives including affording more recreation, such as fishing, jet boating and bird watching; and if we want to be able to provide the social services that we have come to regard as our right, then I believe that there is no immediate way of achieving these ends, with existing resources, other than through the intensification diversification of land and water use.

It is gratifying to note that the Rakaia Resource Survey Report refers to the possible options of storage of water to enhance low flows, and to the possibility of salmon enhancement facilities. Clearly this will require imaginative thinking, and supporting engineering and biological skills for the immense stimulus this resource could give to our economic and social health.
Finally, I would like to say a word or two about the current irrigation-financing policy. Deferment of interest and principal for three years reflects a good understanding of the technology and time lags involved with irrigation development. However, the loss of the suspensory loan on 50 per cent of a component of the on-farm development and the loading of 30 per cent of the off-farm work, together with the relatively short-term amortization of loans, seems to me to spell the end of large-scale border-dyke schemes for sheep and cattle farming.

If we refer to on-farm costs only, and take full development costs at $1500/ha, (that is for earthworks, dams and sills, pneumatics, refencing, stock water, capital, fertiliser and regrassing), and accumulate interest at 9 per cent, the debt servicing would be $300/ha — say $30 each additional stock unit. This may be feasible for dairying, but I doubt it; $1.50/kg milkfat.

There is no doubt, however, that the proposal has been favourable for the development of spray irrigation for cropping and, perhaps, for small-scale strategic drought-insurance systems for pastoral farming. If the intention was to discourage the development of large-scale border-dyke schemes for pastoral farming, then I think it likely to succeed. However, this seems to me to be a judgement about the future viability and economics of sheep and beef farming for which there is probably no greater validity than there ever was in making such judgements in the past, and it is very disturbing in relation to economic growth in this region.
A modelling approach to assessing the risk of alternative stock policies under irrigation and dryland

Dr. T. D. Heiler *, Dr. A. M. Nicol †, and Mr P. Dewar *,
†Lincoln College, *New Zealand Agricultural Engineering Institute.

INTRODUCTION

Pastoral livestock farming, both with and without irrigation, depends on the matching of feed demand of an appropriate livestock policy with the seasonal pattern of pasture production. Feed demand is a function of a number of animals and their feed requirement; influenced by reproductive rate, purchases and sales of stock, and on the physiological state and level of production of the animals.

Feed supply is not only a function of the seasonal rate of pasture growth, but is modified by carrying feed forward, either in situ or as conserved feed.

Matching feed demand in the short term (days) and medium term (months) with feed demand is the science of grazing management and feed planning together with the art of stockmanship. Considerable effort has been given lately to better defining some of the important criteria through feed budgeting, controlled grazing systems and the like.
When long-term planning decisions are required, such as are involved in large-scale irrigation development, or in the intensification of pastoral enterprises in underdeveloped rangeland, recognising the variability that exists in feed supply over seasons and years becomes increasingly important. Predicting the effect that this variability has on the probability of major policy decisions reaching their objectives is necessary. We contend that major pastoral decisions, such as stock policy, stocking rate, percentage of land irrigated, supplementary feed policy and so on, should be considered over the long term at both the farm and regional level.

For a number of reasons consideration of long-term implications of policy decisions has not been adequate. Decisions affecting the long term are often based on short-term information; memories are short. Long-term variability is often not assessed; calculations are long. In combination, these constraints result in little quantification of the risk associated with decision making.

We believe that better planning information can be provided by developing computer models that make use of historical records of climatic data, incorporate known biological relationships, and allow the implications of policy decisions to be assessed over the long term. Our objective in this paper is to illustrate the possibilities of this approach by studying the risk associated with alternative stock policies, with and without irrigation, in the area of the proposed Central Plains Irrigation Scheme.

OVERVIEW OF APPROACH TAKEN

The study involves two computer models. The first is a simple pasture production model that predicts the dry matter production, under dryland and irrigated conditions, from readily available long-term climatic data. The output from this model, monthly dry matter production estimates, forms the input to a livestock policy/feed demand model, hereafter called the animal model.

The animal model develops a feed-demand profile for various stock policy options, and allows the implications of policy and management decisions to be estimated.

DETAILS OF PASTURE MODEL

Introduction

There have been a number of attempts to develop mathematical models of pasture growth in New Zealand (Fick, 1978; Wright and Baars, 1976), and there is considerable interest in such models at the present time. The objectives of current projects are varied. At the more detailed level, interest is focussed on the use of models as an aid to a better understanding of the factors affecting pasture production and the more efficient design of experimental programmes. Simpler pasture models are being used as part of computer-based studies of total resource development projects, for example in current studies of the Central Plains Irrigation Scheme by various planning agencies.

The degree of modelling complexity appropriate for any purpose must be judged in relation to the influence that increasing complexity has on
decisions based on the results of the model study. In describing the details of the pasture model used as part of this study, no claim is made that the level of the modelling is appropriate. The interaction of grazing management and pasture production is perhaps the most complex of all pasture-modelling problems. Details of our model are given to illustrate a very simple approach to a complex problem; to stimulate more work in pasture modelling, and to allow an appreciation of the influence of the pasture model on the results of the animal model.

**Model details**

The basic assumption involved in the pasture model can be expressed as follows, for any day of the year:

\[
\text{ADPG} = \text{MDPG} \times \text{DF}
\]

(1)

Where

- ADPG is the Actual Daily Pasture Growth (kg/ha/day),
- MDPG is the Maximum Daily Pasture Growth (kg/ha/day) to be expected on any day when all growth conditions (fertility, radiation, temperature, cover, soil moisture) are non-limiting, and DF is a dryness factor whose value can lie between 0 and 1.0 and is a function of soil moisture status on any day.

Note that the only source of growth restriction incorporated in equation (1) is soil-moisture variation. All other factors are considered to be non-limiting.

Considering first the source of information for MDPG. Monthly irrigated-pasture production figures are available for the Winchmore Irrigation Research Station. Table 1 shows the maximum monthly production recorded over 13 years (1957–1969) from Radcliffe (1979).

<table>
<thead>
<tr>
<th></th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum Pasture Prodn. (kg/ha/month)</strong></td>
<td>234</td>
<td>192</td>
<td>291</td>
<td>990</td>
<td>1581</td>
<td>1590</td>
<td>1796</td>
<td>1801</td>
<td>1483</td>
<td>1457</td>
<td>900</td>
<td>496</td>
</tr>
<tr>
<td><strong>MDPG (kg/ha/day)</strong></td>
<td>7.8</td>
<td>6.2</td>
<td>9.4</td>
<td>33.0</td>
<td>51.0</td>
<td>53.0</td>
<td>58.0</td>
<td>58.1</td>
<td>53.0</td>
<td>47.0</td>
<td>30.0</td>
<td>16.0</td>
</tr>
</tbody>
</table>


The value of MDPG used in the model for each day in a particular month was taken to be the value given in Table 1 divided by the number of days in the month.

The effect of soil dryness in reducing the MDPG values has been studied by various workers. The approach adopted in this study is based on Garwood and Williams (1967), who found that MDPG is maintained so long as
Dryness factor (DF)

![Graph](image)

Per cent soil moisture available

**FIGURE 1: Dryness factor (DF relationship).**

60 per cent of the total soil moisture is available to the pasture, and that production decreases linearly below this level to zero when the soil has reached wilting point (100 per cent depletion). The relationship for DF in equation (1) is shown in Figure 1.

To operate equation (1) on a daily basis requires that estimates of daily soil moisture must be available. This is carried out in the model using a daily water balance which takes account of daily rainfall, daily potential evapotranspiration, soil dryness, and irrigation if appropriate. Details are given in Heiler (1981).

**Model results**

The model as described above was run using climatic data recorded at Darfield, assuming a total available water store of 75 mm. In the absence of recorded pasture dry matter production at Darfield, comparisons were made between model predictions and recorded data from Winchmore. The model was run in the dryland mode and in an irrigation mode which assumed that irrigation was applied whenever soil moisture levels dropped to 25 per cent of available soil moisture, and sufficient water applied to correct the soil moisture to 75 per cent of available soil moisture.

Table 2 and Figure 2 compare the annual and monthly estimates of pasture production from the model with data from Winchmore (Radcliffe, 1979).
### TABLE 2: Annual pasture production comparisons between model estimates and Winchmore data.

<table>
<thead>
<tr>
<th></th>
<th>Annual Dryland Prodn. (kg/ha)</th>
<th>Annual Irrigated Prodn. (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Dev.</td>
</tr>
<tr>
<td>Winchmore (13 yrs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1957–1969)</td>
<td>5870</td>
<td>1100</td>
</tr>
<tr>
<td>Model (13 yrs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1957–1969)</td>
<td>6850</td>
<td>2150</td>
</tr>
<tr>
<td>Model (42 yrs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1939–1980)</td>
<td>7090</td>
<td>1990</td>
</tr>
</tbody>
</table>

**FIGURE 2:** Monthly pasture production comparisons between model estimates and Winchmore data.
Discussion of results

Model estimates have been prepared using climatic data from Darfield and the only comparisons made are with recorded production data from Winchmore. Therefore, comment is only possible in a general fashion about whether the model estimates are reasonable.

The only agronomic input to the simple pasture model was MDPG — the maximum recorded monthly irrigated pasture production over 13 years at Winchmore. Manipulation of MDPG values in the model resulted in estimates of mean annual and monthly pasture production for irrigated and dryland pastures that showed encouraging similarity to the recorded Winchmore data. The results of this simple exercise support the contention of some current researchers that there are good prospects of reliable predictive models of pasture production, as a result of work at present in progress.

DETAILS OF ANIMAL MODEL

Introduction

There are a number of possible philosophical approaches to the design of an animal component of a feed demand-feed supply model. The approach taken in this model is simple. A required level of stock performance was set for each livestock enterprise. The seasonal feed demand for each class of stock was determined from the required level of production.

This concept allows for comparisons between different classes of stock, stock policies, and number of stock in matching any given monthly feed supply. Flexibility in terms of lambing and weaning dates is provided, but the model determines the pattern of stock sales. Because the model runs continuously over some 40 years, critical time periods where feed demand and feed supply do not match acceptably and, perhaps, more importantly, the risk of such occasions can be quantified.

The model compares the ability of various stock policies and stocking rates to work rather than considering the consequences of failure. While this approach may be satisfactory for planning exercises, it may be quite unsuitable for short-term decision making where an interaction between the animal and feed supply may be required.

Structure of animal model

The general structure of the model is shown in Figure 3. Each month the feed available is allocated by priority to the animal feed demand. Surplus feed is either carried forward in situ or conserved as hay. A feed deficit is accommodated by selling stock, feeding supplements or identifying the shortfall in feed availability. Descriptive variables and rules are required to define the above structure. For each livestock enterprise the following is required on a monthly basis:

* the daily energy requirement (MJME/day).
* the minimum residual dry matter herbage mass (post-grazing) in kg DM/ha associated with the energy intake.
* the relative priority of each class of stock for pasture.
* a maximum proportion of the dry matter (DM) intake which can be supplementary feed.
* the potential for sale or purchase of stock in each month.
* the estimated carcass weight of stock sold in each month.

At present, four livestock enterprises have been defined:
1. A breeding ewe flock.
   — 55 kg ewe rearing 120 percent lambs to weaning and producing 5 kg wool. Lamb growth rate 250 g/day pre-weaning.
2. Lambs (post weaning to slaughter).
   — all lambs, export and replacement, have a weight gain, post-weaning, of 150 g/day.
   — replacement ewe lambs become hoggets on April 1 (35 kg liveweight) and increase in weight to 40 kg by end of July and to 55 kg by mating as two-tooths.
   — a finishing cattle enterprise buying weaner steers (180 – 200 kg liveweight) in April, gaining 0.5 kg/day during winter (260 kg in September) followed by 1.0 kg/day for 100 days in spring and 0.6 kg LWG/day till slaughter from January to March.

Variables at present used for each of the four livestock enterprises are listed in Appendix 1. Liveweight patterns are based on Scott et al. (1981) and Binnie (1983); metabolisable energy requirements are those used by Ulyatt et al. (1980); post-grazing residual dry-matter figures are based on Milligan (1976), and relative priorities for feed, plus potential for purchase or sale of stock, were determined by acceptable farming practice. Any of these variables or livestock systems can be altered if desired.

![Diagram of feed demand - feed supply model](image-url)

**FIGURE 3:** Structure of feed demand — feed supply model.
Feed surplus and deficits

The present rules governing feed surpluses and deficits, after feed demand and supply are compared within any one month, are:

Pasture dry matter surplus is carried forward *in situ* to the following month unless it is greater than 30 per cent of feed demand when pasture (>20 per cent of feed demand) is conserved with a 75 per cent efficiency and accumulated. If pasture DM carried forward to the following month is not consumed within that month it decays by 50 per cent.

Where feed demand is greater than supply, the decision may be made to sell stock, if acceptable for that month. Stock of lowest priority are sold first, and only sufficient stock are sold to equate feed demand and supply in that month. Alternatively, supplementary feed may be fed to the limits shown for the various classes of stock. The quantity of supplementary feed used is deducted from the feed reserves or, if necessary, purchased.

Should the combination of these strategies for equating demand with supply still result in a deficit, the deficit will be recorded as such, and the computation made for the next month.

Model output

Output from the model shows the monthly balance of stock numbers, pasture and supplementary feed available, surplus or deficit, and calculates the annual output of wool, beef and sheep meats.

Results

The animal component of the model has not yet been subjected to rigorous validation, but has been used to illustrate the information which a model of this type can generate.

(a) Per-ha. and per-animal output

The model responds to increasing stocking rate (Table 3) with an increase in output of lamb/ha although with diminishing returns. Carcass weight/head decreases with increasing stocking because of the earlier sale of lambs at the higher stocking rate, rather than decreasing liveweight gain of lambs since liveweight gain is a constraint for all stocking rates. These results are typical of sheep stocking-rate experiment (Joyce et al., 1976), and suggest that the simple decisions made by the model are reflecting real changes in output.

<table>
<thead>
<tr>
<th>Stocking rate (SU/ha)*</th>
<th>15</th>
<th>17.5</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lamb carcass (kg/ha)</td>
<td>180</td>
<td>195</td>
<td>208</td>
</tr>
<tr>
<td>Lamb carcass weight (kg/lamb)</td>
<td>16.5</td>
<td>15.5</td>
<td>15.0</td>
</tr>
</tbody>
</table>

* Mixed age ewe flock, rearing own replacement under 100 per cent irrigation.

**TABLE 3:** Predicted output of lamb carcass weight/head and /ha for a range of stocking rates.
(b) Stock policy and irrigation

The risk of a disaster month, a month in which feed supply is less than 70 per cent of feed demand, for a stocking rate of 12.5 SU/ha in two stock policies, (a) one-year ewes, buying in all ewes in each year, and (b) a mixed-aged ewe flock, 25 per cent replacements, with 0 to 25 per cent area irrigated is shown in Figure 4.

Stock policy or irrigation had little impact on the risk of a feed shortage in September or October, but in neither of these months was the risk high, not more than one year in eight. In November, irrigation of 25 per cent of the area reduced the risk of a substantial feed shortage on both stock policies from one-in-three years to one-in-five years. Irrigation was not required under a one-year ewe policy in December, March or April, when ewes could be sold in December, but with the mixed-aged ewe policy severe feed shortage, in at least one in every three years, were recorded in December and March. Irrigation of 25 per cent of the area eliminated the feed shortage in March and April.

This set of results shows how choices of stock policy and area irrigated are critical in achieving acceptable matching of feed demand and supply.

![Figure 4: Influence of stock policy and irrigation of risk of disaster (less than 70 per cent feed demand).](image)

(c) Supplementary feed reserves

Results from the model studies illustrated the sensitivity of supplementary feed supplies to stocking rate. For example, a 15 per cent increase in stocking rate from 15–17.5 SU/ha, with a self-maintaining ewe flock under irrigation, changed the system from one which had a large conserved-feed
surplus over the whole 42 years of 50 kg/SU/year to self-sufficiency in conserved feed. A further increase of 14 per cent lead to a major shortfall in conserved feed of 25 kg/SU/year (Figure 5).

Although, overall, supplementary feed was in balance over the 42 years at 17.5 SU/ha, in 16 of the 42 years feed conserved was not sufficient to meet the requirements of the following years. Four of these years were in succession. Complete self-sufficiency in conserved feed would have required a reserve of 350 kg/SU or 350 t/1000 SU (14,000 bales of hay) to overcome the worst four-year period.

These results suggest that moderate changes in stocking rates could be used as a strategy for either replenishing stocks of supplementary feed or reducing excessive reserves.

\[
\begin{align*}
\text{Conserved feed (kg/SU)} & \quad 50 \\
+ & \\
\text{25} & \\
- & \\
15 & \\
17.5 & \\
20 & \\
\end{align*}
\]

**FIGURE 5:** Average annual conserved feed/SU with changes in stocking rate (breeding ewe flock rearing replacements under 100 per cent irrigation area).

**REVIEW OF THE OBJECTIVE OF THE PAPER**

The stated objective of this paper was to study the risk associated with alternative stock policies, with or without irrigation, in the Central Plains area. It was decided, in the pursuit of this objective, that risk would be quantified by specifying the desired animal performance levels of a particular stock policy, and recording when the system failed to meet these performance levels. The approach taken did not attempt to quantify the economic significance of failure; simply to record the number and severity of failure occurrences.

The method adopted must therefore be regarded as an intermediate step in the modelling possibilities for this type of problem. A considerable amount of information is given about the success or failure of pastoral enterprises in the long term, and as such the method has the potential to improve present decision-making processes.
Model complexity would have to increase dramatically if the economic consequences of failure were to be sought. The information base necessary for a model of this type would be extensive, and perhaps not readily available at present.

LIMITATIONS OF THE MODEL

Pasture Model

Any modelling approach of this kind would require a pasture model to provide the input to the animal model. Information produced by the animal model would be only as good as the pasture model predictions. The model described in this paper has not been validated, simply checked as being reasonable.

In theory, the pasture model is capable of estimating dry matter production under conditions where irrigation water may be restricted. This capability was not used in this study to reduce the complexity necessary in the animal model, although this could be done. The pasture model is based on recorded dry matter data from cutting trials at Winchmore. There is a lack of information as to how these data relate to dry matter production under grazing conditions, and also how grazing management affects dry-matter production in the long term.

Worthwhile developments in pasture modelling in New Zealand are expected to be made in the next few years. As reliable pasture models become available, much greater confidence will be placed on the use of joint pasture-animal models of the type discussed in this paper.

Animal Model

Considerable refinement of the animal model is also required. Some of this refinement would be in areas which have not previously been well defined, but which can have major effects on the model output. Many of these areas would not be easily identifiable as critical in the absence of a modelling approach. For example, a change in the arbitrary decision as to when the conserve feed, say 20 or 30 percent above feed requirement, and what surplus remains after conservation, 0 or 10 per cent, was shown to have a major influence on not only supplementary feed reserves, but the success of a livestock system. There is little information on the appropriate values for these input data.

Similarly, the decision whether to sell stock before feeding supplements, or to supplement in preference to selling stock, also has a large effect on the long-term output and success of the system.

The ability of a livestock system to carry forward feed in situ, particularly during periods of feed shortage, is important in the allocation of feed resources. The carry forward of pasture in the present model is limited to periods of feed surplus and to changes in the residual dry matter. Improvements in the capabilities of the model in this area could be made.
CONCLUDING REMARKS

We believe that, with developments and refinements in the approach described in this paper, the model could have important contributions to make to the long-term planning aspects of pastoral development. The pasture and the animal-model algorithms used have shortcomings; we would wish to be assessed on whether the concept of linking the information contained in long-term climatic data with known biological relationships, with the purpose of studying the long-term risk of various kinds of pastoral enterprise, is a worthwhile one.

REFERENCES


# APPENDIX I
Details of monthly input to animal model for the four stock enterprises.

<table>
<thead>
<tr>
<th></th>
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<th>J</th>
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<tr>
<td><strong>Metabolisable energy intake (MJ ME/head/day)</strong></td>
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|       |     |     |     |     |     |     |     |     |     |     |     |     |
| **Residual dry matter (kg DM/ha)** |     |     |     |     |     |     |     |     |     |     |     |     |
| Ewes  | 400 | 400 | 700 | 900 | 1000| 1200| 1200| 600 | 900 | 1200| 1200| 800 |
| Hoggets | 600 | 600 | 600 | 600 | 1000| 1200| 1200| 1200| 900 | 900 | 900 | 800 |
| Lambs | 700 | 700 | 700 | 700 | 1000| 1000| 1100| 1100| 1100| 1100| 1000| 1000|
| Cattle | 900 | 900 | 900 | 900 | 1000| 1200| 1200| 1000| 1000| 900 | 900 | 900 |

|       |     |     |     |     |     |     |     |     |     |     |     |     |
| **Feeding Priority (1 = highest, 4 = lowest)** |     |     |     |     |     |     |     |     |     |     |     |     |
| Ewes  | 3   | 3   | 1   | 1   | 1   | 1   | 1   | 4   | 4   | 1   | 1   | 3   |
| Hoggets | 1   | 1   | 2   | 2   | 2   | 2   | 2   | 3   | 4   | 2   | 2   | 2   |
| Lambs | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 1   | 4   | 3   | 3   | 4   |
| Cattle | 2   | 2   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 2   | 2   | 2   |

|       |     |     |     |     |     |     |     |     |     |     |     |     |
| **Proportion DM intake as supplementary feed** |     |     |     |     |     |     |     |     |     |     |     |     |
| Ewes  | 0.8 | 0.8 | 0.3 | 0   | 0   | 0   | 0   | 0.6 | 0.6 | 0.2 | 0.2 | 0.6 |
| Hoggets | 0.6 | 0.6 | 0.6 | 0.6 | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Lambs | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Cattle | 0.5 | 0.5 | 0.5 | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |

|       |     |     |     |     |     |     |     |     |     |     |     |     |
| **Change in number (0 = no change, 1 = sale, 2 = purchase, 3 = either sell or buy)** |     |     |     |     |     |     |     |     |     |     |     |     |
| Ewes  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 1   | 3   | 3   | 3   |
| Hoggets | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| Lambs | 1   | 1   | 1   | 0   | 0   | 0   | 1   | 1   | 1   | 1   | 1   | 1   |
| Cattle | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 1   | 1   | 1   | 2   | 2   |

|       |     |     |     |     |     |     |     |     |     |     |     |     |
| **Carcass weight (kg)** |     |     |     |     |     |     |     |     |     |     |     |     |
| Ewes  | 20  | 19  | 18  | 17  | 16  | 15  |     |     |     |     |     |     |
| Hoggets | 22  | 22  | 22  | 22  | 22  | 22  |     |     |     |     |     |     |
| Lambs | 12.0 | 13.5 | 14.5 | 15.0 | 15.5 | 16.0 |     |     |     |     |     |     |
| Cattle | 200 | 210 | 220 | 225 | 230 | 235 |     |     |     |     |     |
Late spring grazing management

T. P. Hughes, Animal Sciences Group, Lincoln College.

Every spring, for a short time, pasture growth invariably exceeds animal demand. Herbage mass increases leading to a sward with a high proportion of reproductive tillers, and seed heads, rank material and litter. Such material not only provides poor-quality feed, depressing animal performance, but reduces subsequent pasture growth rate, because of shading and a reduced number of actively-growing parts of the plant (tillers). This loss of production may persist through the following summer and autumn, especially in dry areas without irrigation.

The distribution of plant components within the herbage canopy also changes. Reproductive seed heads dominate the top layer. Grazing intake may be reduced as the more preferred leaf is less accessible in the lower parts of the sward, and is mixed with dead material.

The objectives of late-spring grazing management are to prevent these potential losses in pasture and animal performance by controlling reproductive tiller numbers (seed head production), preventing accumulation of rank material, and maintaining the sward in a leafy vegetative state.

This paper will explain why such objectives have been chosen, and how these can be attained.
PLANT GROWTH

Pasture grasses attempt to produce seed every spring to self-propagate and survive. Production of the reproductive-tiller seed head dominates associated vegetative tillers producing leaf. When reproductive tillers predominate, both the number and growth of vegetative tillers is decreased. As a consequence, pasture growth in the late spring is reduced, and a carry-over effect may persist in the subsequent summer and autumn. This carry-over is most pronounced under dryland conditions.

The growth point of the reproductive tiller moves progressively further above ground level as the seed head emerges, and becomes susceptible to removal. If at this stage of growth (normally October) the seed head is removed, either by grazing or mechanically, the reproductive tiller will die. Regrowth will be dominated by vegetative tillers. The grazing animal is only willing to graze this seed head tiller in the early stage of growth because, as it matures, it becomes less digestible.

SWARD COMPOSITION AND ANIMAL INTAKE

Herbage intake or level of animal production usually increases as herbage mass increases. The incremental increase in intake per unit of herbage mass declines rapidly, following the law of diminishing returns, as herbage mass increases. This may occur because the sward increasingly becomes less digestible, having greater proportions of mature stem, seed head and dead material compared with new green leaf. This decreased digestibility is associated with a reduction in the rate of digestion, and passage of material through the animal’s digestive system. This limits the amount of herbage the animal can eat each day. The animal tries to select material of higher digestibility, than that of the average material on offer, to maintain high intakes.

The influence of changes in digestibility, composition and position within the sward canopy on intake as herbage mass increases is shown in Figure 1 for recently-weaned lambs, goats and calves. As herbage mass increased the amount of stem seed head, and dead material increased in the pastures. The animals responded differently in intake to the changes in herbage mass. Lambs had the highest intake when they grazed the short leafy sward with a herbage mass of 1800 kgDM/ha.

While goats may be exceptional in increasing intake with increasing mass, the economically-important animals did not require a herbage mass greater than 2000 kg DM/ha. To maintain the sward in a high-quality state throughout summer herbage in excess of this should be removed as early as possible to maintain the dominance of vegetative parts, as outlined earlier.

SWARD MANAGEMENT

There is no one practical technique for reducing reproductive tiller survival, and the build-up of rank material. However this may be possible with a combination of grazing, conservation and topping.
**FIGURE 1:** Intake in late spring of lambs, goats and calves offered four similar pastures differing in herbage mass.

**GRAZING**

One hard grazing (removal of most leaf) in late October, when most emerging seed heads can be harvested below their growth point, will kill most reproductive tillers, and drive the sward vegetative. This management technique does not decrease spring pasture production. On most properties in late spring the flexibility to reduce stock performance by hard grazing or the adequacy of stock numbers restricts opportunities for this control. However, with set stocking to maintain herbage mass below 1500 kg DM/ha obtaining high levels of removal of reproductive seed heads as well as high animal performances may be possible. Under set stocking the emerging seed head is more susceptible to removal because of the more-frequent grazing of each tiller and the more-prostrate angle of emergence. The time between grazings in rotationally-grazed swards at this time of the year is usually about three weeks. This allows the reproductive tiller unimpaired growth to a stage of maturity where it will be discriminated against by the grazing animal.
CONSERVATION

Conservation of silage or hay aids pasture control by mechanically removing seed heads and rank material. The grazing pressure on the remaining farm area not involved in conservation is increased, making seed heads more susceptible to grazing and preventing the build up of rank material. The duration of this increased grazing pressure depends on the growth rate of the hay or silage aftermath. Silage, offers many advantages as a method of conservation. It can be cut earlier because of less dependence on the weather, which allows regrowth during the more-favourable growth period, is of higher quality, and generally cheaper than other conservation. If the area put aside for conservation proves too optimistic, silage paddocks can be readily re-introduced for grazing. Limited research with sheep shows that when average farm cover exceeds 1700 kg DM/ha in the spring areas should be shut up for conservation.

Topping

To kill the most reproductive tillers, and remove the most rank material the mower should set at ground level. Consequently, a more accurate description of the task would be “bottoming”. As seed-head emergence begins in late October and continues through most of November, topping after mid December is purely for aesthetic reasons and an indication that insufficient area was shut up for conservation purposes earlier in the spring.

CONCLUSIONS

Controlling late-spring pasture growth will alter composition and quality. This increases animal intake and performance as well as pasture production, which may persist until autumn. Control can be achieved by a combination of hard grazing at critical times or set stocking, conservation preferably silage making and topping. As seed-head emergence depends on pasture species and locality, advocating a “recipe” type approach in terms of timing of operations for effectively controlling pastures in late spring is impossible.
Silage quality and animal response

Robin Crawshaw, First Secretary, Agriculture and Food, British High Commission, Wellington.

Computer people have introduced a lot of new jargon into the language. One of the most frequently-used aphorisms is "rubbish in rubbish out". Silage people know there's nothing new in that. In fact, we can go further: "rubbish out, regardless of what was put in". One of the difficulties we must face is that the better the quality of the in-going crop, the greater the chance of an appalling fermentation, and a product, which the stock will be reluctant to eat. Particularly so in the situation often found in New Zealand, where the silage is used as a supplement to other feed. Given a choice, stock will eat very little poorly-fermented silage.

In order to avoid this pitfall — and this can be avoided year in year out, good seasons and bad — attention to the basic principles of silage making is important. For anyone in doubt, a good guide can be obtained from any basic gardening text book which describes the procedure for making compost. If you do the opposite of the instructions, you are well on the way towards successful silage making.
Look at this list of rules for good compost:

- Airy bin construction
- Stalky bottom layer
- Thin layers of grass
- Keep damp
- Thin layers of soil
- Occasional stir.

Remember the most important requirement of good silage making is to keep out the air.

**REQUIREMENTS OF A GOOD FERMENTATION**

Now let's go into a bit more detail. Ensilage is a fermentation process in which grass with an initial pH around 6 is turned into a product with a pH around 4. If kept air-tight, it will remain in good condition for many years.

Figure 1 shows the process graphically. Notice that it takes a lot more acid to lower the pH from 5 to 4 than from 6 to 5.

Some crops are more difficult than others. Lucerne clover-rich swards, and leafy rather than stemmy grass are said to have a high buffering capacity, since these crops require more acid to reduce the pH to a satisfactory level.

![Herbage pH vs Acid needed](image)

**FIGURE 1:** Amount of acid needed to reach stable conditions.
If a sufficiently low pH is not reached, the fermentation is unstable. The spoilage organisms, the clostridia, continue to work with the consequence that the pH begins to rise again. From then on, the longer the crop remains in the silo the greater the wastage of nutrients, and the less palatable it becomes. Figure 2 demonstrates this effect.

Where does this acid come from? From the fermentation of plant sugars. It is impossible to say how much sugar is needed for a successful fermentation, because it depends on which biochemical pathways predominate in the conversion of sugar to acid — some of which are shown below:

- **Homolactic fermentation**: glucose or fructose → 2 lactic acid
- **Heterolactic fermentation**: glucose → lactic acid + ethanol + CO₂
- **Clostridial fermentation**: 2 lactic acid → butyric acid + 2CO₂ + 2H₂

Sugar levels vary in herbage, often in inverse relationship to the protein content of the crop; the higher the protein, the lower the sugar content. The legumes typically have lower sugar levels than grass, and leafy grass has less sugar than a more mature crop. You will notice that this list of crops with a low sugar content corresponds with that given earlier for buffering capacity. This is a sad fact: crops with a high buffering capacity, which need a lot of acid to reduce the pH to a stable level, tend to have a low sugar content and potentially low abilities to produce acid. In other words these are doubly difficult.
What can help boost the sugar content of herbage is sunshine, and on the strength of this some people would advise cutting the crop in the late afternoon when the sugar content is at its highest. I would not disagree with this advice, though it may not always be practical, and it is not something to which I should give top priority.

CONSERVING A DIFFICULT CROP

If you are cutting a difficult crop, what steps can be taken to ensure a good fermentation?

Additives: You could use an additive. There are many different types available in Britain, but the one used commercially with most widespread success is formic acid. I understand this is available in New Zealand too. The basic philosophy is simple: add acid to supplement that occurring as a result of fermentation. This is a very effective treatment because direct acidification reduces crop pH more efficiently than acid produced by fermentation.

There are other additives, some of which could confer extra benefits, and some which are of little apparent benefit and not worth the cost.

However, the point which must be made, first and last, in any discussion of additives, is that good silage can be made without any of them.

Wilting: The chances of successful preservation depend very heavily on the dry matter content of the in-going crop, as shown in Table 1 (taken from a UK survey of over 1100 commercial silages).

<table>
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<th>% Dry matter</th>
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<td>&lt; 21</td>
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<td>31–33</td>
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TABLE 1: Association between DM% and fermentation quality.

Crops with a dry matter content below 21 per cent have a very strong chance of a poor fermentation. Above 23 per cent dry matter content there is quite a good chance of good preservation, and above 30 per cent dry matter content satisfaction is virtually guaranteed, providing that the dry crops can be adequately consolidated and the silos made airtight.

FEEDING VALUE

What about feeding value? This largely depends on the quality of the in-going crop. Leafy crops will have higher digestibilities — more energy and protein — than mature crops. Fed to appetite, these can be expected to lead to better animal performance. However, the ideal stage to cut crops for silage is a compromise which must take into account aspects of both quality and quantity, the class of stock to be fed and the feeding season, and the requirements of good pasture management.
What effect does fermentation have on feeding value? A good fermentation will ensure that the digestibility of the silage is little different from that of the in-going grass. On the other hand, a poor fermentation can reduce the digestibility of the crop significantly. The best evidence I had available in Wellington on the effect of poor fermentation on silage digestibility is shown in Table 2 which summarises the results of 21 trials carried out with formic acid as an additive.

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**TABLE 2:** Effect of formic acid on silage digestibility.

In 11 trials where there was little difference in the fermentation quality of treated and untreated silages the mean digestibility was identical for both groups, and, incidentally, little different from the digestibility of the in-going herbage, though this is not shown. In the other 10 trials, the untreated silages developed poor fermentations which the additive, doing the job it was bought to do, prevented from happening. The mean digestibility of the badly-fermented group was 3.2 percentage units lower.

**FIGURE 3:** The variability of silage intake.
Poor fermentation also reduces the likely intake of silage. This, shown in Figure 3, is taken from some work with dairy cows. Silage intake varied tremendously from 5 to 10.5 kg DM, with a mean of 7 kg. But 59 per cent of herds on well-fermented silage ate more than average, whereas only 23 per cent of herds on badly-fermented stuff exceeded this level.

If you put these two points together, reduced digestibility and reduced intake, the consequence is fairly predictable: reduced performance. If in the winter-feeding situation you are not aiming for maximum intake, the effect of a poor fermentation may seem unimportant, but I should not agree. Greater in-silo losses will already have been incurred with this type of silage, and poor fermentation will lead to increased variation in individual intake.

Remember that a satisfactory average intake does not mean that all stock are being reasonably fed.
Silage on the farm

D. C. Jarman, farmer, Greendale.

Hay is a number one crop in New Zealand, and as long as we export livestock products, this will remain so. New Zealand is one of the only countries in the world that can successfully fatten stock on forage crops, and, for this reason, better use must be made of this product if livestock is going to be as profitable as cash crops.

Under irrigation a lot of lighter land will be opened up for cropping, but this is where livestock should be maintained. What has been built up over the years should not be cropped out. My thought is that forage crops should be intensified for better yields and high livestock numbers, thereby putting more fertility back into the soil.

Hay, although being the number one crop, is the hardest to harvest, and conserve. Different harvesting methods must be looked at so that hay can be used to the fullest. Under present processes of conserving hay, losses of 30-50 per cent at harvesting, storage and feeding can be expected.

Before speaking of my experiences on silage and silage making, I would like to tell you something about my farm. The farm is 202 ha, with 186 ha under cropping, on Templeton silt loam, and there is 16 ha of riverbed runoff. I usually have about 1300 ewes and up to 150 head of fattening cattle. The stock requires intensive use of fodder crops, as most of the farm is
shut up or in crops for at least six months of the year. I buy in all stock, and am prepared to drop any when necessary.

Last year I had 83 ha of straw crops, 38 ha of grass seed and 66 ha of white clover. I lambed 1400 ewes, and brought in 1450 store lambs.

I could not run this much stock without a productive feed for supplements, and silage is the only one for fattening stock. I used to make hay, but so often the quality was poor. Even good lucerne hay was not much better than a maintenance ration, not to mention the hard work, weather conditions, and often having to get up in the middle of the night to make it.

Even if silage cost twice as much as hay, which it doesn’t, there is twice the product. I have been making and feeding silage now for eight years, and have not made a bale of hay in that time. I doubt that I ever will again.

During those eight years I have fattened more than 1000 head of cattle, almost solely on wilted silage and grass seed straw, with some greenfeed crops. Most of the time these cattle have been run on a two to four-hectare feed pad, or shingle ridge, to stop pugging on the heavy land.

Last year was the first year that I ever really fed sheep on any quantity of silage. Realising just how bad the drought was, I decided not to buy in cattle, and fed the silage to the ewes.

My 1400 ewes had 350 t of pasture and lucerne silage, from February 8 to June 8, and again for three weeks in July, to stop ewes going dopey before lambing. The ewes also had as much grass seed straw as they could eat.

I ran the ewes in two mobs of 700, and they stayed on the same paddock for four months while being fed silage. The ewes had good live weight when I started feeding. I fed them for three weeks with 2.5 kg of silage each per day, then gradually cut this back to 1 kg/day with straw. On the higher ration the ewes gained weight for a start, then lost weight rapidly after tupping.

In June we began to feed greenfeed oats, which were pretty miserable. I had problems with nitrate poisoning and lost 40 ewes. After a month on the oats, I decided to put the ewes back on silage along with the oats. I don’t know how many ewes I would have lost had I not done this. I kept the ewes on silage and oats until lambing began at the end of July.

A few of the ewes were dopey with pregnancy toxaemia. Generally, the ewes milked about the same as usual, so I believe silage is as good as young grass at that time of the year.

Feeding the ewes on silage I was able to build up a reasonable reserve of autumn-saved pasture when finally the rain came. Most of the paddocks had good feed for lambing.

I set-stock the ewes in six mobs and started lambing on July 27. Half the lambs were weaned on September 14 and the rest at the end of September, at six-to-eight weeks old.

The first draft of lambs was on October 26, and all the lambs were sold for $20-23. All mobs tailed more than 130 per cent, although I finished up selling 110 per cent from ewes that went to the ram. This was good considering the season.

Wool weights were well down, but I blame this on the previous summer, not the silage.
I certainly could not have run this number of ewes and achieved a reasonably-good lambing without the silage. Apart from the two months of lambing and a little stubble grazing, the ewes were run on 20 ha for the year. I am sure this proves silage can see you right in drought years.

There is nothing new about silage making and feeding. The first reference I found was in an 1886 copy of Farmer magazine. This explained how to use wire ropes and threaded rods to screw down pressure on the stack to exclude air. A reference of 1898 mentioned using wood silos, with a press in the top to make an air-tight structure. So, the principle of good silage making has been around for a long time.

WHAT HAPPENS IN A SILAGE PIT

Chopped plants are dumped in a pit and then heavy rolled to exclude air. The plants continue to respire, burning up sugars, using up oxygen and giving off heat. At the same time, bacteria continue growing until running out of oxygen. Then, hopefully, lactic acid is produced which preserves the ensiled material, unless air is reintroduced. Good silage should be sweet smelling and have a yellow straw colour.

Forage crops are expensive to produce, harvest and conserve, whether baling or making into silage, so as much care should be taken as with harvesting and storing grain crops.

Silage starts with growing the crop. This may be grass, oats, barley, lucerne or maize. All these can be ensiled, with some requiring more care than others.

Clover and lucerne are low in sugar, so need wilting to lower the water content and give the production of lactic acid a better chance. Oats, barley and maize crops are worth thinking about, as these give greater yields and may be followed by green feed crops. Pasture silage yields around 10t/ha, oats 30 t, and maize up to 50 or 60t. Maize is low in protein, and needs to be fed along with 20 per cent pasture grass silage for flushing or as a fattening ration. I have made all these crops into silage and have had good success.

Grass should be cut before going to seed. Crops should be cut in the afternoon, preferably, when plant sugars are highest. Sugar is needed for good fermentation. Other crops, such as oats and barley, I windrow at the hard-dough stage of grain, and maize hard dent stage.

PRE-WILTING IS A MUST

Wilted silage is more palatable and less filling than direct-cut silage, so animals can eat more and put on more weight. Wilting means less weight is being transported. Trucks and trailers can carry more, and there is less material to push around in the pit. Seepage or moisture from the stack is eliminated. I usually mow late afternoon, and start harvesting next morning.

HARVESTING

There are three main types of harvester: chop and blow, double chop, and precision cut. Chop and blow has a flail cutter, which also blows material into a trailer. This type of harvester does not pick up windrow, and does
not cut the material finely. Double chop has a flail-type pickup with a recutter blower, and will cut some crops reasonably finely. Precision cut has a wide-finger pickup, or maybe a corn head. The material passes over two sets of feed rollers to a cutter head, the feed rollers holding the material while the knives cut over a shear bar. This machine can be set to cut at any length from 3.2–76 mm.

The length of cut more or less determines how well the pit will consolidate. All choppers take considerable horsepower, so need to be adjusted properly, have the knives kept sharp, and have the right clearance to the shear bar. Harvesting should start at about 65 per cent moisture level, or when there is difficulty rubbing any moisture out on the hands.

When harvesting I use four men: one on the forage harvester, two carting away, and one spreading and consolidating the pit. We harvest at 20 to 25 t/hr, or 300–375 bale equivalents. This is pretty good, as all the material is in the pit and forgotten about 24 hours after mowing.

**CARTING**

Carting wilted silage is not back-breaking like carting hay. You have to make sure the chopper keeps going. Twenty tonnes of material an hour takes some moving if you have far to go. Trucks and trailers need to be well covered so that wind does not affect flow from the chopper.

**CONSOLIDATION**

Good consolidation is most important in making silage. Unless all air is excluded, the result is compost, not silage. That is why the length of cut at harvesting is important. Long-cut material is springy and won’t pack, but short-cut material virtually packs itself. Spreading the load over the whole pit is important, because by doing this the material is being rolled and consolidated all the time. I usually roll the pit again for about an hour the next morning before covering.

**COVERING**

Covering the pit must be done properly, otherwise this is a waste of time. I have seen many pits which have had the cover lifted by the wind. Then wind and rain gets in and fermentation starts again. Also, making a good job of covering the pit is a wasted effort if the pit is not fenced to keep stock out.

Covering the pit as soon as possible after making silage is important to minimise respiration time. The easiest way to weigh down the polythene cover is to use old car tyres. Each tyre should touch other tyres. This adds weight on the pit, helping force out air.

**FEEDING**

I believe that silage can be fed out a month after making. Stock take readily to silage, and there do not seem to be problems, such as grain poisoning. Stock can be put on to full rations straight away.

Remember, silage costs money so make sure there is no waste when feeding. Feed down fence lines or under electric wires. This prevents the
stock trampling the silage into the ground. The finer the silage, the easier to handle, and at first it can be forked off the truck.

**STORAGE**

There are many different ways of storing silage; a bun on the ground, a pit, bunker silos, baleage, and air-tight or harvester silos.

A bun on the ground is probably the cheapest way, although requiring a much bigger cover and more tyres, but can be wasteful because of the risk of rotting. Using a tractor to consolidate the material can be dangerous.

A pit in the ground is a good alternative, if there is plenty of drainage, and the soil is right for firm sides.

Bunker silos are solid, above-ground structures. These can be made from concrete, or even old car packing cases, poles and wire netting. Another good alternative might be one-tonne Heston square bales for the sides, and I have used round bales with success.

The pit I use is a bunker above ground, with a concrete floor and pre-cast concrete sides, holding 500 t.

Another option is to use baleage, by putting plastic bags around bales. In my opinion, cost is against using this method. The polythene to cover my pit costs 30 cents for each tonne of material; plastic bags, for big bales, cost $8/t of material, and getting two seasons use out of the bags is doubtful.

There are not many air-tight or harvester silos in New Zealand, because of high initial cost. These are glass-lined steel structures, rather like grain silos. Some are 7.5 m across by 18 m high, and hold as much as 1500 t.

These silos can be emptied from the bottom, and loaded from the top, so can be used two or more times a year.

When selecting a site for a silage pit, bear in mind filling will take place only a few days each year, but feeding out could take several months, so a central location handy to the yard is best. The pit should not be too wide as the face should be fed at least once a week.

**HOW MUCH DO WE FEED?**

Stock seem to eat as much as they are given. In my opinion, at times like flushing ewes or fattening cattle stock should be allowed to ad lib feed for the highest lambing percentages, or highest rate of gain from cattle. With cattle I keep feeders full all the time.

MAF recommendations for feeding ewes at flushing, with some picking of pasture as well, are:

- An ewe needs 2.6 kg silage a day
- Four weeks before ram going out multiplied by 2000 ewes 73 kg a head which would take 146 t
- Maintenance ration 14.5 ha pasture 1.4 kg silage a day

I feel these rates are a little low, taking into account the drought we are experiencing.
COSTS

MAF estimates having a contractor do the job would cost about $10/t. That is mowing, forage harvesting, rolling and the cost of cover. This is equivalent to 66 cents a bale for the whole job.

In my situation, I am sharing machinery on the cropping side of the farm, so I can afford to do it myself. My forage harvester cost $10,000, and this is also used at times to get rid of straw residues.

I also had to buy a feed-out wagon, although for cattle I could get away without one.

I feel silaging would be great to syndicate, as there is not so much dependence on the weather. Most farmers have a truck, tractor or trailer. The purchase of a chopper between the syndicate, and with working together, the job could be done when wanted and at reasonable rates.

SOME OF THE ADVANTAGES OF WILTED SILAGE

Here are some of the advantages of and reasons why I changed to wilted silage. This is a good product, with feed value to fatten and increase weight of stock. Silage is fast and simple to make, and there are no weather worries. All handling is mechanical and there is no heavy manual work. Paddocks are left in nice order to fatten lambs, and pastures become clover dominant. Unlike hay, weed seed is not being spread all around the farm. It helps stop seedy pelts, so wool is cleaner. There is no dust, and silage won’t blow away when being fed out. Pink eye in sheep is prevented, and there are fewer losses than with hay. Silage is an excellent drought feed. Pastures can be spelled, while feeding silage, to build up reserves of feed for lambing, flushing or finishing lambs. Making silage can easily be syndicated.
Aspects of sheep thrift on irrigation

Lindsay McKnight, Veterinarian, Waimate.

Originally this paper was to deal with animal health on irrigation, but I have narrowed the topic to aspects of sheep thrift on irrigation.

Irrigation has brought to Canterbury farmers the promise of an assured year-round feed supply, and heralded an end to the trials and tribulations of drought. It brought the prospect of relatively endless supplies of abundant pasture, and the reality of worry-free farming.

Alas, irrigation in the Waitaki Valley, at least, also brought to many farmers a series of new problems, some of which seemed as insurmountable as the long-forgotten droughts.

Fortunately, with time, many of the problems encountered have been controlled, but many remain and these are still serious enough to significantly depress production on many farms.

This paper will be confined to three factors affecting sheep thrift on irrigation: the essential role of nutrition, minerals and micro-nutrients, and gastro-intestinal parasitism.

My sole experience with animal health and irrigation comes from working with farmers in the Morven-Glenavy area of the Waitaki Plains Irrigation Scheme. Much of the data presented has been gathered by Alexander Familton, until recently in clinical veterinary practice in North Otago working
with farmers in the southern part of the Waitaki scheme. He has done a
tremendous job in defining the problems confronting irrigation farmers, and
I am indebted to him for the advice and information he has provided for
this paper.

**NUTRITION IN ANIMAL HEALTH**

Adequate nutrition is essential for the health of any livestock. Because
irrigation brings guaranteed pasture supply, farmers are able to stock farms
highly to make the most efficient use of pasture grown. However, the margin
of error between pasture sufficiency and pasture insufficiency is fine, and
the potentials for disaster many.

Animal health problems arise when there are too many mouths to feed
and stock are chronically underfed, or when there is mismanagement of
the feed grown.

Case studies are a way of illustrating some of the problems farmers run
into.

Chronic under feeding occurs most commonly in ewes during late winter
and early spring. In the early years of the Morven-Glenavy scheme we saw
many problems like this, but, thankfully, the situation is not nearly so com-
mon today.

**CASE STUDY NO.1**

An irrigated farm of 250 ha stocked at about 15/ha, with about three-
quarters of the property border-dyked. The farmer still had a drought philos-
ophy and put the rams out in mid-March. The ewes were not pre-tup
drenched. The farmer went into the winter with less autumn-saved pasture
than desirable, but plenty of lucerne hay. He thought he would get through
all right.

During May the ewes were put in one mob for an all-grass wintering ro-
tation (that is the farmer's term, not mine). The ewes were shifted on to
a new paddock once a week and fed hay on the fourth to seventh day.
In early August, with lambing due to start in three weeks, the ewes were
taken to the yards for crutching. Some drifted behind and could not make
it. After crutching the situation got worse. Some sheep began to die, a num-
ber were dopey, and some began to scour. A big tail end developed, and
within a few days the death rate increased.

Three moribund ewes were submitted for post-mortem. These were found
to have low bodyweights, pale fatty livers, indicating pregnancy toxæmia,
one had aborted, and there were moderately high worm burdens. The gut
of one ewe was sent to the Lincoln Animal Laboratory for a worm count.
The worm count showed the abomasum had 6000 *Ostertagia* and 18,400
*Trichostrongylus*. The small intestine contained 23,800 *Trichostrongylus*.

Obviously, this farmer was in trouble, facing a serious situation with long-
term consequences. He had a flock of light bodyweight ewes, with weight
stripped off during winter, affected by a complicated metabolic disease and
significant parasite burdens. Lambing was approaching, and there was little
prospect of feeding the ewes properly as there was little or no saved pasture
available.
Drenching the ewes stopped the deaths, but the tail end got bigger. Some ewes slipped their lambs, and when lambing started mortality of both ewes and lambs was high.

At lambing the ewes were set stocked out on paddocks with little or no grass. The ewes' intake remained restricted, and their milk production was poor. The lambs got away to a poor start, as it was still only September and the grass was just beginning to move.

What I have just described was once common-place on the Waitaki Irrigation Scheme in the early years. Thankfully, this situation is rare today, but less severe cases still occur.

The basic problem in the case study illustrated was prolonged malnutrition. Poor feeding and disease states are inextricably entwined. Malnutrition predisposes sheep to all kinds of disease.

Sound feed management is often the best medicine, and preventive medicine at that.

What it all comes down to is skilful manipulation of the feed curve. The following is a grass-growth curve for irrigated land in the Waitaki Plains scheme (Figure 1). This shows a great bulk of grass grown during summer, but negligible growth between mid May and September. Forward planning is essential, particularly for feed troughs, and should begin well ahead to ensure ewes can be fed adequately.

**FIGURE 1:** Daily pasture growth on Waitaki irrigation areas (6 year average). [Familton, 1982].
In earlier years, one could travel around the irrigated areas of South Canterbury when lambing had finished and see paddock after paddock looking like billiard tables. Sheep were eating to ground level, and there was no saved pasture anywhere.

I can remember one farmer wryly commenting that his ewes were standing around, heads bowed, waiting for the grass to grow. When they saw a blade of grass come up they chomped it and waited for the next to appear.

![Requirements graph](image)

**FIGURE 2**: Ewe and lamb requirement for pasture from one week prior to lambing to six weeks past lambing at 15 ewes/ha at 133 per cent lambing. [Familton, 1982].

There have been changes since then, on some farms at least, because the feed curve has been managed better, mainly by delaying lambing. Figure 2 shows ewe and lamb requirements for pasture of one week before lambing to six weeks after lambing at 15 ewes/ha and 133 per cent lambing.

If this is superimposed over the pasture production curve for the Waitaki region, we can begin to see where things go wrong. Take the farmer, I talked about earlier, who lambed in mid August. Pasture growth and sheep feed requirements were poles apart. Lambing, for best agreement, should not start before mid September. By postponing lambing the feed requirements of the flock will coincide with the pasture growth curve.

Fortunately, the feed intake of ewes before lambing does not significantly affect subsequent milk production, but by feeding ewes well around and after lambing the effect on milk production and lamb growth rate is startling. This is shown in Table 1.
<table>
<thead>
<tr>
<th>Intake (l/day)</th>
<th>Weight gain (g/day)</th>
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</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
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<td>170</td>
</tr>
<tr>
<td>1.5</td>
<td>320</td>
</tr>
<tr>
<td>2.0</td>
<td>400</td>
</tr>
</tbody>
</table>

**TABLE 1:** Intake and lamb growth from birth to four weeks.

By getting ewes to milk well, you can well afford to delay lambing. Late lambs, with superior growth rates, will soon catch up on earlier lambs that have not been so well fed.

In 1980, Alex Familton examined growth-rate patterns of lambs on 10 farms in the Lower Waitaki area to establish variations between farms. All 10 farms produced fat lambs, and all but two had extensive border-dyke development. On each farm 10 lambs were selected and regularly monitored to assess and measure mineral status, parasitic status and growth rates.

Growth-rate measurements gave the most meaningful results. The growth rate chart (Figure 3) shows that during the first nine to ten weeks of the lamb’s life, under the prevailing conditions, growth rates were extremely critical as far as live weights at weaning were concerned.

**FIGURE 3:** Lamb growth weight.
Growth in this period related very closely to milk production of the ewe, and depended on the quantity and quality of the pasture being eaten by the ewe, and differing milking ability of various breeds. The variation between the farms was 13 kg over the first nine weeks of life, with only a further 0.5 kg difference in the subsequent three weeks.

The high growth rates achieved on some of the farms during the three weeks between weighings could be attributed to better pasture becoming available, as well as starting anthelmintic treatment at 10 or 11 weeks.

Alex drew these conclusions: Serious consideration should be given to re-evaluation of the recommended stocking rate being advocated by many parties until more work has been done to establish optimum production figures. Achieving adequate pasture of suitable quality and quantity is paramount in lamb growth. Many of the farmers could do well to consider pasture production as their first priority.

Disease, nutrition and performance are all interrelated factors that must be considered when looking at production problems or outbreaks of disease. A veterinarian, investigating ill-thrift, can often find from pathological changes in a carcass what the animal died from. He must look much further to find WHY the disease arose. Often malnutrition is a major factor.

**SUB-OPTIMAL LAMB GROWTH AFTER WEANING**

Sub-optimal lamb growth after weaning is a problem on some farms. Alex Familton's growth-rate measurements of young lambs on irrigation in North Otago (Figure 3) show growth after weaning was poor on all farms. Apart from subclinical parasitism, there was no evidence of other disease problems. There is little doubt that pasture quality is a major factor affecting lamb growth, particularly in mid summer.

During veterinary investigation of "ill-thrift" problems in lambs during summer it becomes evident that many factors are involved in precipitating the problems.

This is best illustrated with a further case study and will also serve to introduce my two other major topics: minerals and parasites.

**CASE STUDY NO. 2**

This was a farm of about 100 ha, divided into 13 paddocks, and farmed along with a dryland farm nearby. Early one February the farmer reported that 500 lambs out of 2000 were doing very poorly, and some were beginning to die. Fifteen of the worst-affected lambs were weak and staggery, and could not be shifted. The lambs had been rotationally grazed but grass growth had got out of control, and pasture quality was poor. The lambs had been drenched twice, once about Christmas, and again about 12 days before the problem was investigated. The farmer submitted three lambs for post-mortem.

Pathological changes noted were: the lambs were emaciated, had moderate amounts of serous fluid in the abdominal cavity, the carcasses were pale and seemed anaemic, and there were parasites in the gut.

Laboratory findings from a worm count on one lamb showed 14,300
Ostertagia in the abomasum, and 4300 Nematodirus, 2700 Trichostrongylus and 400 Cooperia in the small intestine.

An animal tissue analysis showed that liver copper and selenium levels were normal, but Vitamin B12 was deficient.

The diagnoses from the laboratory results were of cobalt deficiency and parasitism, with rapid reinfection. The field investigations showed a pasture quality problem.

Here was a farmer in serious trouble, whose only real hope was that he would do a better job the next year.

With regular anthelmintic treatment and cobalt therapy, the lambs would improve dramatically but at the end of the season there would still have been a big clean-up draft of light bodyweight lambs, with a high percentage of seconds.

Veterinarians necessarily see farming from a biased point of view. Obviously, the problems we see are not on every property; we tend to be involved where problems are evident. Many farmers in the Waitaki Plains irrigation scheme region are doing very nicely.

Part of the ill-thrift problems outlined involved cobalt deficiency. This leads into a discussion on the role of minerals in the health of stock on irrigation.

**MINERALS**

The exact role that the various minerals play in day to day stock thrift remains to be elucidated. Many farmers, professional people and others are convinced there are widespread mineral deficiencies adversely affecting stock performance.

Countless farmers who have used mineral drenches or mineral fertilisers of varying kinds have claimed these have improved production immeasurably. However, this assessment has been subjective. When one starts looking for weight-gain responses to mineral treatments with a set of scales, the production gains become much more elusive.

There is no doubt that minerals have a vital function in maintaining animal health. Massive and crippling outbreaks of white muscle disease have occurred, and still occur, in selenium deficient areas when selenium use is discontinued for a time. This is particularly so in growthy years. Most irrigated areas in Canterbury are marginally selenium deficient so continued judicious use of selenium is warranted. However, there is mounting evidence that with frequent dosing, selenium levels in sheep can reach undesirably high levels. Farmers should consult their veterinarians for local recommendations on the use of selenium.

Cobalt deficiency has been diagnosed as a cause of ill-thrift on irrigation. In 1975-76 a severe outbreak of ill-thrift occurred on many farms in the Waitaki area. The next year the problem disappeared.

Since then, scattered marginal deficiencies have been diagnosed on a few farms, but there have been no further major outbreaks. These swings from deficiency to sufficiency appear to be independent of any cobalt treatment to soil or animal. The variable appears to be climate. Deficiency is more likely in growthy years.

The now-you-have-it, now-you-don’t situation of cobalt deficiency is
shown in the results of monitoring cobalt problem farms in Australia (Lee 1963):
In two of the 14 years lambs were unthrifty, but there were no deaths.
In three of the 14 years lamb-growth rate was slightly retarded.
In four of the 14 years 30 per cent to 100 per cent of the lamb crop was lost.
In five of the 14 years the performance was as good as that of the dosed lambs of the flock.
Copper and zinc have been blamed for contributing to ill-thrift problems, but the Lincoln Animal Health Laboratory has no record of either mineral having been proven to be a causative factor in producing ill-thrift on irrigation.
Iodine deficiency occurs sporadically in some areas. On farm, growth-rate trials and lambing performance data, using controls, are required to determine iodine status in marginal situations. Unfortunately, iodine deficiency states seem to follow a similar pattern to cobalt deficiency. A single trial in one year gives information only about that year.
Treating animals or pastures with combinations of minerals has been the practice on many farms lately. Six of the 10 properties surveyed by Alex Hamilton had been topdressed with minerals in this way. The growth rate of lambs on these farms was no better than the lambs grazing untreated pastures.
Alex concluded that applying mixed mineral fertilisers could well be a dangerous practice, because of the interactions that can occur between

![Diagram](image-url)

**FIGURE 4:** Four stages in the events following the introduction of a ruminant to a diet of inadequate copper content. [Suttle, 1981].
many of the minerals which can make some unavailable. The practice should not be carried out until mineral deficiency on a property had definitely been confirmed. Minerals were not the panacea many people had thought as far as treatment of ill-thrift was concerned.

When the mineral requirements of livestock are considered, the ability of body systems to adapt and change are greatly underestimated. Our livestock animals have evolved over millions of years, and have had to cope with deficiencies without the intervention of man. Animals are able to survive, without ill effects, for relatively long periods when diets are deficient in essential nutrients, and remain healthy because nutrients are stored within the body. Just as an animal can live off its fat during winter, so it is able to call on body reserves of minerals and vitamins during periods of inadequate dietary intake.

Recent work on copper deficiency has revealed something of how these systems work.

Figure 4 is a graph of a model representing what happens in ruminants on a copper-deficient diet. On the vertical axis the trace element content of the pool within the body is shown, while the horizontal axis shows the duration of depletion, with four stages: depletion, deficiency, disorder, and debility.

When, for whatever reason, copper absorption from the gut is not sufficient to meet daily requirements, stored body reserves of copper are used. These are chiefly in the liver, but copper levels in a wide range of tissues also decline. The stages of depletion and deficiency can be detected biochemically, but the animal shows no outward sign of debility. Not until body reserves of copper are almost depleted do clinical signs of copper deficiency appear. How long it takes for debility to develop depends on the intensity of the deficiency, and other factors such as molybdenum intake.

In summary, then, there remains a great deal of research to be done, particularly with regard to marginal deficiencies, before the interaction and effects of all minerals and micro-nutrients on stock health are defined.

However, in general, I believe that at present mineral deficiencies are over-diagnosed. Many of the problems attributed to mineral deficiency, when investigated, are found to be caused by other factors. Injudicious use of minerals, especially combinations of minerals, could well make an existing ill-thrift problem worse.

GASTRO-INTESTINAL PARASITISM

There is little doubt that internal parasites are the greatest threat to animal health on irrigated land. Although some farmers have the problem under control, parasites limit production on most irrigated farms.

Parasites cause more production loss on irrigated land than in most dryland farming. There are several reasons for this. Frequent watering and lush grass provide an ideal microclimate for the development and survival of the free-living stages of gastro-intestinal parasites. High-stocking rates and mob stocking make good use of pasture, but more larvae are picked up in hard grazing as 90 per cent of the free-living parasite larvae are in the bottom inch of pasture. Clean pastures are hard to achieve because
fewer hay and fodder crops are grown, the cattle-to-sheep ratio is lower, irrigated blocks are usually used for young stock, and spelling time of pastures is minimal because of high summer pasture production.

Clinical parasitism in lamb ill-thrift, as mentioned earlier, is only the tip of the iceberg. The real problem is subclinical parasitism, when stock show no overt sign of disease, but growth and performance are significantly affected.

Once diagnosed, clinical parasitism is easily controlled, but adequate control of subclinical parasitism is more difficult, and on some farms almost impossible.

Well, what are the effects of subclinical parasitism, and why is it such a problem.

Brunsden, in a review paper in 1966, concluded that lambs carrying relatively-light infestations, although appearing to thrive, were 10-20lb lighter at the end of the first 12 months than uninfected twin lambs, and the loss of weight was never regained.

No research has yet been published on the average intake of parasite larvae by sheep grazing irrigated pasture. However, Professor Sykes has estimated that under New Zealand pastoral farming conditions larval intake is likely to vary from 2000–60,000 larvae a day.

Research has shown that a constant intake of about 4000 larvae a day reduces appetite, and food intake can drop by as much as 20 per cent. Fat and protein deposits in the body are markedly reduced and the intestinal lining, particularly the villi, are damaged. There is a leakage of protein into the lumen of the gut. These additional secretions are reabsorbed lower in the gastro-intestinal tract, but the body has to synthesise much extra protein which would have otherwise been used for growth.

Skeletal development is also affected. Poor calcium and phosphorus retention in subclinically-affected sheep result in decreased growth of long bones, and thinning of existing bone. Even when the infection has gone, normal bone growth may not be restored. This may explain Brunsden’s statement that loss of weight throughout the growth period is never regained.

There have been studies to find the effects of larval challenge on lamb growth rate. Table 2 shows that an intake of just 5000 larvae per day halves the growth rate.

More interestingly perhaps, growth rate is still significantly affected despite three weekly drenches.

<table>
<thead>
<tr>
<th>Numbers of larvae:</th>
<th>0</th>
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<tr>
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<td>100</td>
<td>73</td>
<td>51</td>
<td>64</td>
</tr>
<tr>
<td>* anthelmintic at 16-day intervals</td>
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<td></td>
<td></td>
<td></td>
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</tr>
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</table>

**TABLE 2**: Effect of rate of ingestion of ostertagia larvae and anthelmintic therapy on depression of growth rate.
<table>
<thead>
<tr>
<th>Date</th>
<th>Abomasum</th>
<th>Intestine</th>
<th>Intestine</th>
</tr>
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<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Av</td>
<td>HC</td>
<td>Av</td>
</tr>
<tr>
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<td>6</td>
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</tr>
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<tr>
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* "Specimens for Laboratory Examination" (1975). Ministry of Agriculture and Fisheries.

Av = average, HC = highest count, PB = pathogenic burden

**TABLE 3**: Parasitology results from the Morven fungicide trial, 1976–77.
LARVAL PICK-UP AND REINFECTION RATES

During the 1976–77 summer a pasture-fungicide trial was carried out on the Morven-Glenavy irrigation scheme. Lambs were set stocked on plots from December 9 until March 15, and were drenched every 17 days. One lamb from each of six groups was slaughtered every three weeks. Results are shown in Table 3.

There was no sign of ill-thrift among the lambs and they grew at an average rate of 145 g/day, in spite of some of the lambs having quite high burdens at times.

At what rate would these lambs have progressed with lighter burdens?

CONTROL OF GASTRO-INTESTINAL PARASITISM

My experience is that in many situations, especially on irrigation, the parasite control recommendations of the Animal Production Society sub-committee failed to control parasitism adequately.

A new set of recommendations on preventive drenching has been published, but much needs to be done urgently so these can be applied and made to work on irrigated farms.

Effective control must be based on an understanding of the population dynamics of the parasites, and how they might be influenced by the effects of watering, management of the sheep, and drenching practices. There are many gaps in our knowledge, and research is needed before sound advice can be given in all situations.

The aim of control procedures should be to limit contact between the parasite and host to minimise production losses, but still provide sufficient challenge to stimulate host immunity. Remembering that host resistance is enhanced by good nutrition is also important. Parasitism cannot be considered in isolation.

Programmes have relied on providing what has been termed safe pasture. I think nearly every farmer, veterinarian and adviser has a concept of clean pasture, and I think nearly all of us are wrong. We tend to underestimate the ability of the free-living stages of the common gastro-enteritis parasites to survive on pasture.

Angus Dunn, in his text on Veterinary Helminthology, comments: "Given an even cool temperature, a year's survival is possible for most trichostrongylid pre-parasitic stages, but it is probable that in the fluctuating conditions of the field, survival periods are in the order of six to eight months."

He goes on to say: "Freezing is much less lethal than formerly thought, and most larvae can survive the moderate winters of temperate regions. Dessication and high temperatures (more than 30 degrees centigrade) are the greatest killers of the free-living larvae."

These two factors are not frequently encountered on irrigated land. *Nematodirus* species are able to survive on pasture for even longer periods. Investigations in Central Otago have shown that viable *Nematodirus* larvae (retained within the egg) could be isolated from pasture for up to 70 weeks after grazing by lambs which had deposited eggs there.
These are startling facts when one considers that on some irrigated farms only sheep are grazed, all paddocks are in permanent pasture, and little or no hay is made. There is little chance to achieve clean pasture.

What control methods are available to farmers to minimise contact between grazing stock and the free-living stages of gastro-intestinal parasites resident in pasture?

The following has been adapted from recent papers given by Dr Dave West, of Massey University:

Theoretically, safe pasture can be achieved by grazing and pasture management, integrated control, or by means of anthelmintic treatment, or a combination of these.

**GRAZING AND PASTURE MANAGEMENT**

Providing safe pasture must fit in with grazing-management systems, which will nearly always take priority, but these can have a beneficial effect on parasite challenge.

New pasture, hay and silage aftermaths, all initially provide safe pasture, but on most farms the area of land is not enough to provide more than a few weeks respite from larval challenge. Rotational grazing was seen to offer a useful means of reducing pasture infectivity, but the periods of resting even for dryland (four to five months in autumn-winter; two to three months in spring-summer) are obviously unacceptably long.

Little information is available on the development time under New Zealand conditions for eggs to reach maximum yields of infective larvae on pasture, but that this may take from two to six weeks is generally accepted. More detailed work on *Ostertagia* and *Trichostrongylus* gave times of 33 and 36 days respectively.

Grazing rotations on irrigation are similar to these times and farmers, thinking they have clean pasture, could be exposing their sheep to maximum numbers of infective larvae.

Alternate grazing by sheep and cattle has been proved to be effective in reducing pasture contamination on some farms, but with present sheep-cattle ratios this would be practical for only a few.

Adult animals are generally more resistant to helminths. This is because older animals generally reject a higher proportion of ingested larvae and have lower levels of worm output in faeces, so alternate grazing should lessen the exposure of younger animals.

This usually does work admirably, and ewes can act as effective vacuum cleaners of parasite larvae.

However, this can break down, and does so when larval challenge is so high that some larvae reach adulthood and begin laying eggs. The ewes can then be seeding the pasture with significant numbers of worm eggs. It also occurs when stress factors reduce ewes' resistance. Recent work by Julie Wagner, at Ashburton, has shown that stressed hoggets and ewes produce significantly increased faecal egg worm counts. Ewes and hoggets become contaminators rather than vacuum cleaners. Two thousand ewes each producing 2 kg of faeces a day, with a mean worm egg count of 250
eggs/g, would seed the pasture with 1000-million parasite eggs a day. That is not efficient "vacuum cleaning."

Although integrated control has been shown to work, this is impractical on most irrigated farms, because of the requirement for long periods of pasture spelling. For example, a major requirement of integrated control is a drench and a move of lambs in late November or early December to a pasture not grazed by ewes and lambs from the start of lambing until weaning. Providing sufficient safe pastures at critical times for all lambs is not possible with existing stocking rates and cattle-to-sheep ratios.

The options discussed so far have some limitations, and these control systems tend to break down at times. This leads to consideration of producing safe pasture by means of anthelmintic treatment. This is a relatively new concept, and has involved a complete turn-around in the philosophy of controlling parasitism by using anthelmintic treatment. The graph (Figure 5), probably familiar to many of you, helps us understand the change.

![Graph showing seasonal pattern and origin of infective nematode larvae on pasture grazed by lambs.](image)

Key: 
- O, overwintered larvae
- E, larvae originating from the post-partum egg output of ewes
- I, larvae originating from the egg output by the lambs themselves.

These larvae produce the first generation of worms in lambs.

These larvae result in the second generation of worms which is responsible for subclinical or clinical disease.

**FIGURE 5:** Seasonal pattern and origin of infective nematode larvae on pasture grazed by lambs.
The graph shows seasonal availability of trichostrongyloid larvae on sheep pasture, in relation to sources and periods of contamination. Except for *Nematodirus* spp., which differs in that infection can be transmitted through the pasture from one season's lambs to the next, other sheep parasites behave in much the same way.

Larval numbers are highest in autumn, and this is when the lambs are likely to pick up the greatest burdens. Further, various New Zealand drench trials have generally shown greatest response in autumn.

In 1975, a New Zealand Society for Animal Production sub-committee recommended that lambs should not be drenched at weaning, but should be given three drenches at four-to-six weekly intervals beginning in February. The intention was to clean out worms that had been picked up from pasture contamination in the autumn. Many farmers have since used variations of this, and begun drenching a little earlier and more frequently.

As cattle numbers dropped, stock numbers went up and irrigation became more widespread, these recommendations were seen not to be working adequately. The autumn larval challenge was just too high.

Meantime, the significance of subclinical parasitism in depressing growth rates became clear.

As a result, of these findings, the idea evoked that anthelmintics should be used regularly with the primary objective of reducing pasture contamination of larvae.

The change in philosophy has been from using anthelmintics to rid lambs of significant worm burdens to using anthelmintics to prevent significant burdens ever being picked up. This is taking a preventive approach, rather than a treatment approach.

Now, let us go back to the pasture contamination graph (Figure 5) to see how this works.

Theoretically, the major source of infection for lambs is the larvae deposited on the pasture by the ewes around lambing time. In fact, on problem farms and especially where *Nematodirus* is a problem, a big component comes from over-wintering larvae.

The lambs pick up the larvae when they begin grazing. Resistance is low when the lambs are young, and a few worms, causing no sign of ill-thrift in the lambs, produce large numbers of eggs. Julie Wagner, in her Ashburton work, found that eight week old lambs started producing helminth eggs.

The eggs are deposited on the pasture, then hatch and contribute to the larval build-up, culminating in a peak in autumn. Now the intention of preventive drenching is to drench lambs earlier and more often to minimise helminth egg production, and lessen autumn accumulation of larvae.

Once a larva is picked up by a lamb the worm takes 25-30 days to reach full egg production. Using the preventive approach, lambs should be first drenched no later than at 10–11 weeks of age, and then every three to four weeks until midwinter. The interval between drenches depends upon the farm, and is best worked out between farmer and veterinarian.

On many farms where ewes also contribute to pasture contamination, pre-lambing and post-lambing ewe drenching should be considered. If there is doubt, the local veterinarian should be consulted. Faecal samples can be submitted to determine egg counts.
Unfortunately, results of these new programmes have not yet been fully evaluated in New Zealand. However, some farms have been monitored and the effects of the programmes on worm egg production, hogget-growth rates, and wool production have been encouraging.

There are three disadvantages of the preventive approach: (1) The cost; the outlay on drench is significant, but this is outweighed by the potential benefits, as the cost of subclinical parasitism has been very much underestimated and drenches remain relatively cheap. (2) Interference with development of host resistance, but the programmes outlined are still likely to give enough exposure to infection for resistance to develop (3) The possible development of anthelmintic-resistant strains of parasites.

The development of anthelmintic-resistant strains is the major disadvantage of the preventive approach, and is a very real worry. Little resistance has been detected so far on New Zealand farms, but is likely to appear with ever-increasing frequency in future. If no better way can be found than advocating that farmers should spend a great deal of time with a drench gun in their hands then resistance will become a major problem.

I believe major research is needed throughout New Zealand, particularly in irrigated areas, to understand more thoroughly the biodynamics of sheep parasite populations, and associate these with climatic factors. This information may be used to time anthelmintic treatments more sensitively.

The number of anthelmintic treatments delivered to stock must be reduced, or eventually there will be populations of superworms, just as the medical profession is faced with antibiotic-resistant super staphylococci.

Meanwhile, all farmers should follow the recommendations for minimising the build-up of resistance. DRENCH ACTION FAMILIES MUST BE ALTERNATED ANNUALLY. If alternated at longer intervals, or not at all, resistance to that family is more likely to develop. If alternated more frequently, say in consecutive drenches, resistance will take longer to develop, but the result could be a parasite population resistant to both groups. Then you are in real trouble.

In summary, I would like to remind you of the three major topics discussed today:
* Malnutrition is a major cause of ill-thrift on irrigation.
* Minerals and mineral combinations if used should be used sparingly and only with hard evidence that minerals are deficient on the property.
* Gastro-intestinal parasites are a major factor limiting production on irrigation. Preventive drenching is the most effective way of controlling parasites. More sophisticated methods for parasite control must be developed or drench resistance will become a problem very soon.

REFERENCES


N.Z.A.P.S. Centennial Award — 1983: Mr Graham E. Fieldhouse

Murray G. Hollard, former Reader in Dairy Science, Lincoln College.

The skill and ability of Mr Graham Fieldhouse in establishing and managing high-producing pastures was recognised in 1978 by the N.Z. Grasslands Association in presenting him with a Grasslands Memorial Trust Award. Now, on this occasion, the Animal Production Society of New Zealand wishes to extend the recognition of Mr Fieldhouse to include his success in the efficient use of high-producing pastures with a grazing dairy herd.

I consider having been invited by the Animal Production Society to prepare and deliver a suitable oration to mark the occasion a notable honour.

The prime objective of a pastoral dairy farmer is to produce a large amount of higher-quality grass, over as long a period of the year as possible, and then to convert this animal feed, grass, into human food, milk, as efficiently and profitably as possible.

With dairy cattle, the efficiency of such conversion can be quite impressive. Some 20 per cent of the feed energy consumed by a cow is recovered in the milk, while protein-conversion efficiency will be about 30 per cent. Compare these efficiency figures for milk production with those for beef production at 8 per cent for energy and 15 per cent for protein, and with
those for lamb production at 6 per cent and 10 per cent.

Therefore the perspicacity of Graham Fieldhouse in choosing to be a dairy farmer, rather than indulging in less-efficient beef or lamb production, is immediately apparent. There are many dairy farmers in New Zealand regularly producing high yields of milkfat from pasture, and a small proportion of them, some two per cent, achieve an output of more than 400 kg fat/ha/year.

Graham Fieldhouse, who is in this two per cent, achieves this production at Rongotea, well-known for cold winds and erratic rainfall, and his farm includes much sand-dune country. Had Mr Fieldhouse chosen to farm in Kaponga or Cambridge, he could have led New Zealand in milkfat production.

Mr Fieldhouse showed rather more wisdom when choosing his wife, for the success of the property has been a husband and wife affair, with much help from an interested daughter. Patience, together with an intuitive understanding of the needs of stock and the sensible use of good records, have made stock-handling productive. In the dairy shed, hygiene standards and milking efficiency have always been high, as shown by intelligent use of somatic cell counting records. In addition, the decor of the shed has frequently been enhanced by the judicious use of pot plants by Mrs Fieldhouse.

Like many farmers, and farm supervisors, Graham Fieldhouse has never been short of advice. His association with the consulting officers of the N.Z. Dairy Board has been particularly close, especially with the late Mr Don Johnstone. Extensive use of the property has been made by discussion groups of farmers for the collation of specialised survey data. Research people, and particularly Dr K. R. MacMillan, have used the herd extensively for cow-fertility and mating studies. University lecturers, from both Lincoln College and Massey University, have found his property invaluable as a teaching aid.

A characteristic of Mr Fieldhouse, which this Award is intended to recognise, is his unstinted co-operation with research, extension and teaching people over many years. Personally, I have had many groups of students over the property to discuss dairy production methods with him. Such occasions are critically important to a lecturer in providing some realism and substance to what might otherwise be a rather sterile academic dissertation, greeted by students with reservation, if not stark disbelief.

In New Zealand, these days, some 55 per cent of all dairy cows in over 60 per cent of all herds are mated with artificial breeding, and Mr Fieldhouse has participated in the dairy Board’s A.B. Programme for at least 25 years. The national gain from the use of artificial breeding is about 22 kg milkfat/cow/year, and, over cows sired by A.B. proven bulls, about 28 kg fat/cow/year. The Fieldhouse herd probably has a breeding index of 124, because of the long-term use of artificial breeding. This figure indicates genetic merit of a very high standard. A significant proportion of the high milkfat production a hectare achieved on this farm is because genetically-superior stock is used in harvesting the pasture produced.

Finally, to ensure that a high proportion of the pasture available is consumed by the herd at a phase of their productive cycle when their need is highest, a high degree of skill is required in manipulating drying-off dates, calving dates and in allocating feed on a day-to-day basis. Mistakes, or
misfortune, in such aspects of herd management can be costly in terms of unrealised production. Proficient herd managers like Graham Fieldhouse, have appreciated the intimate relationships of these factors for many years, and have, therefore, profited from their sheer managerial skill.

Mr Fieldhouse has had many roles in the dairy industry: dairy company director, active membership of the Livestock Improvement Association, host to numerous dairying visitors from overseas, and close associate of many people concerned with research, extension and teaching in dairy production, as well as with other dairy farmers.

For all those activities, we seek to recognise his merit by presenting him with the 1983 Centennial Award.

EARLIER RECIPIENTS

The N.Z.A.P.S. Centennial Award was initiated at the time of the Lincoln College Centennial in 1978. It is awarded to the farmer who has made a substantial contribution to the College by either hosting student field trips with a strong stock emphasis or supervising students practical work.

Earlier awards were made to:

Future land use and production in the central plains irrigation scheme

J. P. Greer, Farm Advisory Officer, Ministry of Agriculture & Fisheries, Lincoln.

INTRODUCTION

In this paper the work which a group in the Ministry of Agriculture & Fisheries is doing to assist planning for the Central Plains Irrigation Scheme is discussed. This will give you, as farmers, an indication of the changes which will probably take place in this area over the next 10 to 20 years, and also highlight the relevance of the other papers at this conference.

In August last year a group of MAF farm advisers met to discuss irrigation development in Central Canterbury. The North Canterbury Catchment Board was preparing a resource report, as a basis for a water allocation and management plan for the Rakaia River. The group met to ensure the agricultural need for water was thoroughly evaluated. A particular concern was that the effects of restrictions on the use of Rakaia water were estimated as accurately as possible.

The group decided the following should be done:

* The maximum possible area that could be included in the Central Plains scheme defined.

* Farming systems presently in the area described.
* Farming systems which could be developed under irrigation predicted.
* Irrigation methods likely to be used on each of those farming systems described.
* The amount of water required for irrigation on each of those farming systems assessed.
* The effects on each farming system of restrictions in water availability because of low river flows or low groundwater levels assessed.

Although assessment of the quantity of water required for irrigation is the main concern, predicted changes in land use are of interest, and it is those predictions that are discussed in this paper.

Since these questions were also relevant to other divisions of MAF, the group was expanded to include staff from the Research, Economics, and Fisheries Research divisions as well as the Advisory Services.

**METHODS OF IRRIGATION**

Before describing the present land use, and likely future land use, I would like to emphasise that within quite wide limits the method of irrigation is not dictated by the source of the water.

Historically, river-supplied schemes have been developed into intensive pastoral farming, using border-dyke irrigation, while individual farmers have usually applied groundwater with sprinkler irrigation on to cash crops.

Technically, using groundwater in a border-dyke system with a buffer storage dam is quite feasible as is applying water from a river-supplied scheme with spray-irrigation.

In the Waiau Plains Irrigation Scheme at least 18 farmers are using or planning to use spray irrigation, and I know of several farmers who are using buffer storage dams and border-dyke irrigation to apply groundwater.

The opinion of our group is that ground contour, farm type, soil type, farm size, labour and water availability are the main factors determining irrigation methods. Generally, cropping farmers choose sprinkler irrigation, while border-dyking best suits pastoral farms, irrespective of the source of water. Of course, capital cost and running cost are important, but these are usually determined by the factors already mentioned.

**AREA OF THE CENTRAL PLAINS IRRIGATION SCHEME**

Estimates of the area of the Central Plains Irrigation Scheme (CPIS) vary. Hadfield, Johnson and Le Couteur (1974) assumed that the scheme would cover 88,000 ha between the Rakaia and Waimakariri rivers and between the 250 m contour and the Main South Road.

Maidment, Lewthwaite and Hamblet (1980) assumed the scheme would cover 128,000 ha between the Rakaia River and the Old West Coast Road and between the 250 m contour and the 30 m contour.
The area our group chose to consider in our calculations is shown in Figure 1. The maximum possible area was included, recognising that when a scheme was finally constructed some of that area would be supplied from groundwater. By including the maximum possible area in our calculations we would be able to estimate the maximum demand for water from the Rakaia River and also estimate the demand likely to be placed on groundwater reserves.

The area shown in Figure 1 covers 148,000 ha, including 50,000 ha below the Main South Road.

FIGURE 1: Land use areas in the Central Plains Irrigation Scheme.

PRESENT AND FUTURE LAND USE

To estimate future land use, seven areas within the scheme were defined on the basis of soil type and present land use. In each area there were some farms already irrigated and predictions of land use under irrigation were based on changes which have already occurred on these farms. I will briefly describe each of these areas.

Area 1 (15,600 ha) — This includes the deep soils, with a water holding capacity of at least 100 mm. It includes Barrhill, Hatfield, deep Paparua and deep Templeton soils.
Present land use is estimated at half crop and half grazing with the grazing area carrying 10 SU/ha. With irrigation the cropping will increase to 80 per cent of the area. The remaining 20 per cent will carry 20 SU/ha.

Area 1a (10,600 ha) — Includes the deep heavy soils with some drainage problems at the bottom end of the scheme. It includes Wakanui, Temuka and Waterton soil types. This land is used for intensive cropping (70 per cent) and dairying (30 per cent). Much of the area is already irrigated and no change in land use is predicted. The carrying capacity is estimated at 20 SU/ha.

Area 1b (7,500 ha) — Includes the medium soils (Waimakariri and Paparua) around Southbridge. Much of this area is already irrigated. Land use at present is estimated at 80 per cent crop and 20 per cent stock, carrying 20 SU/ha.

Area 2 (27,500 ha) — Includes the medium soils (mainly Chertsey) with a water holding capacity of 80–100 mm.

Land use in this area is presently mixed cropping with 35 per cent of the area in crop and 65 per cent in stock with a carrying capacity of 10 SU/ha. With irrigation cropping will be increased to approximately 80 per cent of the area. The remaining grazing area will carry 18 SU/ha.

Area 3 (36,200 ha) — This includes the lighter soils (Lismore) north of the Selwyn River, with water-holding capacity varying from 50–80 mm.

Sheep farming on pasture and lucerne, with some forage crops and a little cereal cropping, is the present land use. The estimate is that only 15 per cent of the area is in cash crop, and the carrying capacity of the grazed area is 10 SU/ha. Predictions are that with irrigation 70 per cent of the area would be in crop, and that the grazed area would carry 18 SU/ha.

Area 4 (33,100 ha) — This includes the lighter soils south of the Selwyn

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Area</th>
<th>Crop Area</th>
<th>Stock Area</th>
<th>Stocking Rate</th>
<th>Total SU</th>
</tr>
</thead>
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<td>148,000</td>
<td>36,275</td>
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TABLE 1: Summary of present land use
River, except for the recent soils adjacent to the Rakaia River. Waterholding capacity is between 40 and 65 mm.

Presently, this area carries sheep on pasture, lucerne and forage crops at 8 SU/ha. Predictions are the area would carry all stock at 17 SU/ha when irrigated.

**Area 5 (17,500 ha)** — includes the light recent soils adjacent to the Rakaia River. They have low water holding capacity of 30–50 mm. The farming systems are the same as in Area 4.

A summary of the present land use in the area is given in Table 1. At present 36,275 ha of the area is devoted to cash crops and the area carries a little over 1 million stock units.

With irrigation and the predicted change in farming system, area in crop would about double to 73,240 ha, while stock numbers would increase by about a quarter of a million to 1.3 million stock units (Table 2).

This indicates that with the change to irrigation in Central Canterbury, the area north of the Selwyn River would see a big increase in cash cropping. The area south of the Selwyn River would see an intensification of stock (mainly sheep) production.

Our group is using this information as the basis for assessing the area's water requirement for irrigation. This is being done by the New Zealand Agricultural Engineering Institute using a computer model of an irrigated farm.

<table>
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<tr>
<th>Category</th>
<th>Total Area</th>
<th>Crop Area</th>
<th>Stock Area</th>
<th>Stocking Rate</th>
<th>Total SU</th>
</tr>
</thead>
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<td>3,120</td>
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<td>62,400</td>
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<td>(80%)</td>
<td>(20%)</td>
<td>(20%)</td>
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<td>10,600</td>
<td>7,420</td>
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<td>(80%)</td>
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<td>22,000</td>
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<td>195,480</td>
</tr>
<tr>
<td></td>
<td>(70%)</td>
<td>(30%)</td>
<td>(30%)</td>
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</tr>
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<td>4</td>
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<td>33,100</td>
<td>17</td>
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<td></td>
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<td></td>
<td>(100%)</td>
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<td>—</td>
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<td>297,500</td>
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<td>(100%)</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>148,000</strong></td>
<td><strong>73,240</strong></td>
<td><strong>74,760</strong></td>
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<td><strong>1,321,680</strong></td>
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</table>

**TABLE 2:** Summary of predicted land use under irrigation

**CHANGES IN PRODUCTION**

The increase in stock numbers and production (estimated at 3 per cent increase on Canterbury's sheep production) is probably not sufficiently large to create additional processing or marketing difficulties. This is probably especially so with the increased flexibility in stock selling which comes with irrigation. One change which could be large enough to affect other Canterbury farmers is the likely increased number of trading stock which
would be associated with the cash-cropping programme. Ten store lambs a hectare possibly would be fattened in categories 1, 2 and 3, an area of 79,300 ha or a total of 790,000 store lambs.

Quite clearly the increase in cropping area would be sufficiently great to have a major impact on crop processing and marketing in Canterbury.

Figures prepared from the 1979–80 Agricultural Statistics and MAF Seed Certification data (Cummings, pers. comm.) give the following estimate of present crop areas in Malvern, Paparua and Ellesmere counties (Table 3).

Table 4 shows the present crop production from the scheme area. Assuming that the proportion of each crop is the same within the scheme boundaries as in the three counties, and that the yields are the same.

Table 5 shows the predicted crop production from the scheme area assuming that the proportion in each crop remains the same and applying estimated crop yields.

**TABLE 3: Estimated crop areas in Malvern, Paparua and Ellesmere counties**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Yield (t)</th>
<th>Total Yield (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>8,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>13,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>2,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peas</td>
<td>3,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Clover</td>
<td>8,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass seed</td>
<td>3,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>1,000</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38,500</strong></td>
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</table>

**TABLE 4: Present crop production in CPIS.**

<table>
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<th>Crop</th>
<th>Area (ha)</th>
<th>Yield (t)</th>
<th>Total Yield (t)</th>
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<tbody>
<tr>
<td>Wheat</td>
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<tr>
<td>Oats</td>
<td>1,885</td>
<td>2.9</td>
<td>5,465</td>
</tr>
<tr>
<td>Peas</td>
<td>3,330</td>
<td>2.75</td>
<td>9,075</td>
</tr>
<tr>
<td>White clover</td>
<td>7,540</td>
<td>0.280</td>
<td>2,110</td>
</tr>
<tr>
<td>Grass seed</td>
<td>2,825</td>
<td>0.850</td>
<td>2,400</td>
</tr>
<tr>
<td>Potatoes</td>
<td>940</td>
<td>24</td>
<td>22,560</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>36,275</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Total yield of cereals and peas combined is predicted to increase from 78,840 t to 245,415 t, or approximately three-fold. This is equivalent to a 48 per cent increase in Canterbury's production of these crops.

The yield of grass seed and clover seed is predicted to increase from 4510 t to 10,040 t, or about double. The increase of 10,565 ha in small seeds is equivalent to a 34 per cent increase in Canterbury's area of white clover and ryegrass seed.

These figures are equal to a 25–30 per cent increase in New Zealand's crop production.

If these increases in crop production occurred the marketing of the products would be likely to be more competitive and farmers would need to be more efficient. Possibly, also, an increase in production of this magnitude would lead to a change in the proportion of the area devoted to each crop.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Yield (t)</th>
<th>Total Yield (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>15,220</td>
<td>5</td>
<td>75,100</td>
</tr>
<tr>
<td>Barley</td>
<td>24,730</td>
<td>5</td>
<td>123,650</td>
</tr>
<tr>
<td>Oats</td>
<td>3,805</td>
<td>5</td>
<td>19,025</td>
</tr>
<tr>
<td>Peas</td>
<td>6,660</td>
<td>4</td>
<td>26,640</td>
</tr>
<tr>
<td>White clover</td>
<td>15,220</td>
<td>0.350</td>
<td>5,330</td>
</tr>
<tr>
<td>Grass seed</td>
<td>5,710</td>
<td>1.000</td>
<td>5,710</td>
</tr>
<tr>
<td>Potatoes</td>
<td>1,895</td>
<td>30</td>
<td>56,850</td>
</tr>
</tbody>
</table>

**TABLE 5: Predicted crop production in CPIS**

From the point of view of our group these changes in production do not have major significance. We are mainly concerned about the future water demand.

If different crops were grown these would be unlikely to greatly alter the overall pattern of water requirement; for instance, if the area of horticulture in Canterbury doubled, this would still cover only 7500 ha.

The discussions our group have held with local horticulturalists indicate that the maximum horticultural water requirement may not be substantially greater than the maximum cropping water requirement, although the pattern of water demand may differ. A change from stock to crop would have the greatest effect on the pattern of water demand since the peak demand would be shifted from January and February to November and December. We will be testing various crop-pasture mixes to assess the effect of a shift in water demand.

The predicted increases in crop production have major implications for the growers and marketers of Canterbury's crops. The need for further research on crop marketing was recognised by Professor J.G.H. White, head of Lincoln College Plant Science Department, who, in his inaugural address last year said that for further developments in cropping in Canterbury, re-
search and development into transport and marketing of our products was the most important but the least researched.

The need for this research is made more urgent by the magnitude of the likely increases in production.

Similar development is already taking place in the Lower Rakaia and Barrhill areas, and in parts of South Canterbury. Staff of MAF at Ashburton have estimated that up to 94,000 t of wheat, barley and peas and 11,700 t of clover and ryegrass seed could be produced in the Lower Rakaia and Barrhill areas.

**DIVERSIFICATION**

At the moment, diversification out of sheep into dairying, deer, or even goats are possibilities. On areas suitable for cropping, diversification into vegetable crops for processing, and into horticultural enterprises is possible. These developments would depend on markets being available rather than on the farmer's ability to grow the products. On the other hand, the change to cropping could be even greater than predicted.

In the longer term, improvement in soil structure and fertility, which occurs under irrigated pasture, may make it possible to grow crops in most of Area 4 as well.

**CONCLUSION**

The development of irrigation in Central Canterbury, either in a public scheme, or with private irrigation, would cause a dramatic increase in crop production and a substantial increase in sheep production. The type of crops and stock grown would depend on the market opportunity for each product. The magnitude of the predicted change in land use and production indicate that further research in crop marketing is urgent.

**REFERENCES**


Cummings, J.E., pers. comm.


The present cropping scene

Mr K.R.B. Shipley, farmer, Greendale.

The contribution I can make to these proceedings is to tell you about production increases that have come about on our farm since we started irrigating eight years ago.

For those of you who have recently put in schemes, or are in the process of doing so, I hope this may give you added confidence in the decision you have made. To those of you thinking of irrigation, I hope this will give you a base to help you make a decision.

Our farm is an integrated sheep and cropping unit at Charing Cross, 16 km inland from the main South Road at Norwood, and 11 km from Darfield, our local centre. Average rainfall is 635 mm, and soil type is stony to very stony Lismore silt loam.

Like many of you here, I have experienced many drought periods, and, with these, the problems, worry and stress created by serious feed shortages.

I started farming on my own account in 1959. The 486 ha farm was carrying 1350 breeding ewes and 350 ewe hoggets, growing 8–20 ha of wheat, and grass seed was harvested as a cash crop whenever possible.

With an increased programme of liming and topdressing, re-sowing with certified grass, clover and lucerne, and subdivision, carrying capacity
gradually increased. Ten years later, in 1969, there were 4075 stock units, with an unchanged cropping programme. That year was also the beginning of a drought period, which lasted until 1975, and only a minimal increase in stock numbers took place.

Fertility had reached a reasonable level, but the restricting factor was lack of moisture. Large reserves of hay had been used up, and I was forced to buy quantities of barley, fodder beet, sheep nuts and straw.

In 1971–72 conditions were very similar to those at present. I had to decide, like some of you are having to decide now, what I was going to do about the drought and feed situation.

I had several options and looked at them very carefully.  
* I could reduce stock numbers, but with the conditions that prevailed at that time, would still have had to buy-in large quantities of feed.  
* I could buy grazing. But this was not readily available and simply a short-term remedy.  
* I could buy more land in a higher-rainfall area, but the high capital outlay required, the movement of stock, some 9–12 km, and the management problems involved were, in my view, against this option.  
* Irrigation seemed to be the answer, but were we prepared to take the risk of sinking a well? There was no evidence to suggest there was sufficient underground water available in the quantities required, and there were no other irrigation wells within 6 km.

I was a member of the Irrigation Committee at the time, and knew there would be no major irrigation schemes in the Central Canterbury area in the foreseeable future.

The dramatic increase in the price of wool in the 1972–73 season gave me further incentive to consider irrigation. I used the Income Equalisation Scheme to level out income, and decided I would sink a well. I worked very closely with my farm accountant, who had a real knowledge of the farm, and was very helpful in making the final decisions.

I then approached a well-drilling firm. They as good as told me I would be wasting their time and my money in sinking a well for irrigation in our area.

This was discouraging, but wool prices were again at a reasonably high level in 1973–74 and I again used the Income Equalisation Scheme still with irrigation in mind.

In the autumn of 1974 we decided to proceed with sinking a well, and, at the same time, the well-drilling firm first approached came back looking for work.

Somewhat reluctantly we commissioned this firm to sink a 254 mm diameter well at $92/m (there was no 305 mm casing available at the time). The well sinking started with little enthusiasm from anybody, except for Mr Clem Crosby, of the Ministry of Agriculture and Fisheries. He brought two geologists from Canterbury University when the well was down to about 49 m, and they both discounted the possibility of getting more than a household water supply.

However, Clem Crosby remained enthusiastic. At about 62 m the well was developed and tested. To our delight the well yielded about 21 l/sec with only a 250 mm draw down.
FARM PLAN

We then installed a scheme to cover 178 ha. One block of 97 ha and one of 81 ha, using two power rolls and one unit. After three seasons we put in a larger pump, and brought a fourth sprayline.

The total cost of installation was $55,000, and I borrowed what was required from the Rural Bank. I expected there would be a writing-off period of five-to-six years, but the results were such that it was written off after only three years.

Obviously the best way to use the water available, and therefore receive maximum returns on the investment, was with an increased cropping programme and to hold stock numbers at existing levels.

Previously most cropping efforts had not been successful. Wheat had been the most reliable crop averaging about 2.35 t/ha, barley averaging about 1.68 t/ha, grass seed about 450 kg/ha, white clover had only once been successful yielding about 150 kg/ha.

The one effort made at growing peas had been a total failure. We sowed about 270 kg/ha, it set in dry at the flowering stage and we harvested about 336 kg/ha.

Our major concern was the effect a cropping programme would have on soil fertility and soil structure. It had taken 15–20 years to reach a reasonable fertility level, and we did not wish to see this disappear because of irrigation and cropping.

It was, therefore, essential to use a cropping rotation, so we decided on the following rotation, and eight years later see no reason to make any basic changes. It is a rotation that supports the stocking programme as well as the cropping programme.

The rotation for the 97 ha block consisting of six 16 ha paddocks is: wheat; greenfeed — fallow; grass seed; first-year white clover; second-year white clover.

We will look at this in more detail, and please note we are using the land and water for a mixed sheep and cropping system.

After harvesting the wheat, the stubble is grazed heavily, burnt and sown into grass and oats for greenfeed. This is used for ewes and lambs in the early spring. The re-growth is grazed until late November and then ploughed and left to fallow until early February.

The paddock is then sown with 9 kg of basic Nui ryegrass, about 1.36 kg basic white clover and 170 g of York Globe turnips.

The turnips are fed off for winter feed, and the paddock is then shut up for grass seed.

After the grass seed is harvested, an average of 120 big bales of grass seed straw is baled. The paddock is then irrigated twice, and saved for flushing ewes from late March onwards.

It is then grazed until mid September, when the grass is sprayed out and the paddock is shut up for first-year white clover.

After the white clover is harvested, the paddock is grazed very heavily and then greenfeed oats are direct drilled. The oats are fed off as the crop and season demands, and then sprayed out in mid September. The paddock is then shut up for a second-year crop of white clover.

After harvesting the paddock is again heavily grazed and oats are direct
drilled. The oats are fed off when mature, usually mid May to mid June. This is then used for a run off for the turnips which creates a build up of nitrogen for early spring-sown wheat.

The only change we have considered making is substituting the second-year white clover for peas. This rotation maximises both stock and crop, it builds fertility and preserves the soil structure.

The sixth paddock, grazed for the entire period mainly because of being required for the movement of stock, is irrigated three to four times from mid January and used for flushing ewes from early March onwards.

On the other 81 ha irrigated block we have about 20 ha in lucerne and we use a five-year rotation also: peas; white clover; barley; pasture; pasture.

<table>
<thead>
<tr>
<th>Dryland Yield/ha</th>
<th>Irrigated Yield/ha</th>
<th>Range Irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>2.35 t</td>
<td>4.57 t</td>
</tr>
<tr>
<td>Barley</td>
<td>1.68 t</td>
<td>5.47 t</td>
</tr>
<tr>
<td>Peas</td>
<td>0.34 t</td>
<td>3.83 t</td>
</tr>
<tr>
<td>Grass seed (once only)</td>
<td>448 kg</td>
<td>717 kg</td>
</tr>
<tr>
<td>White clover (once only)</td>
<td>178 kg</td>
<td>504 kg</td>
</tr>
</tbody>
</table>

TABLE 1: Average results from cropping

As I said earlier, our intention was to hold stock units at the existing level when we started irrigating. However, quite an increase in numbers soon took place. In the five years before irrigation the average stock units carried were 4350 and in the six years since the average has increased to 5500.

During the period from 1969 to 1980 the dryland-farming average lambing percentage was 103 per cent, and since irrigation was installed the average has risen to 116 per cent.

Now, looking at total wool production we see a considerable increase. However, of more interest is the increase of wool weights per hectare from 34.1 kg/ha before irrigation to 39 kg/ha after irrigation.

However, it must be remembered that the 1969–75 period was very dry and from 1976–80 was very favourable, therefore the total increase cannot be attributed solely to irrigation.

As well as farm production increases, there have also been financial increases.

Total farm income increased 291 per cent for the five-year average since irrigation. Total farm expenses (not including standing charges) increased 344 per cent and total net income increased more than 300 per cent.

However, inflation not irrigation created those figures.

To give a more realistic look at the financial gains from irrigation, using 1970 as a base to equal 1000 and the consumer price index to bring the
results into real money terms, the result is a 37.5 per cent increase in real net income in the change from dryland to irrigation.

**WATERING CROPS**

As with all farming, doing the right thing at the right time is very important, and with irrigating crops even more so. We apply 70 mm of water each shift.

We grow certified Oroua wheat and certified Gwylan barley for seed production. The first watering is very important, and better too early than a little late. The wheat usually requires two or three waterings, and the barley three or four waterings. The Gwylan barley has averaged 6.73 t/ha with four waterings over the last two seasons.

**PEAS:** We grow garden peas for seed production and these usually require three waterings at early bud formation, flowering, and pod fill.

**RYEGRASS:** As the least productive, this is our sacrifice crop if there has to be one, and usually only gets two waterings and so the poorer results.

**WHITE CLOVER:** From first flowering onwards, white clover must be kept going on light land, and usually gets three waterings.

**HARVESTING:** Our normally very-dry summers are a help here. We have not used any defoliating sprays, often we have too little bulk rather than too much with clover. Stones are a problem of course, with heading crop off the ground.

**LABOUR:** If any one tells you irrigation doesn’t make more work — don’t believe them. With four spray lines, shifting morning and night and, probably two or three paddock shifts, we spend about 30 man hours a week on irrigation.

Surprisingly, we have done this without any extra manpower. At present we use two sons and a Lincoln College student from November to February. This includes working a 130 ha cropping area we bought three seasons ago.

**SPRAYLINE MAINTENANCE:** Maintenance of the sprayline has been less than expected. Some sprinklers now need to be replaced after about 20,000 hours.

**PUMP MAINTENANCE:** The first pump was replaced for a larger one after 6000 hours and it cost $3,000 to change over. After another 14,000 hours, the second pump is undergoing a major repair job expected to cost $6,500. This averages $1,000 a year for pump maintenance.

**WATER SUPPLY:** The future water supply is a major worry. The static level has dropped to 46 m, and if this rate of fall continues this time next year there will not be sufficient water for irrigation. As a comparison, we have a NCCB Test Well, 2 kms N.E. of our well, with records since 1952. This
well was dry in 1972 and will again be dry in 1984 if the present decline continues.

WEEDS: Weeds have not yet become a real problem, but yarrow and docks in white clover, and fathen in the crops cause concern. I hope chemical companies are working on something that will take yarrow out of white clover.

PLANT AND MACHINERY: The large capital outlay required in purchasing machinery must be a major consideration for a farmer changing to cropping with irrigation. Fuel costs also rise dramatically with the change to cropping.

SEED CLEANING: This is one of the off-farm costs small seed producers have to put up with. A 200 kg/ha field-dressed crop of white clover with a 25–30 per cent dressing loss can cost more than $124/ha in cleaning charges.

POWER COSTS: One of the big disincentives to irrigation is the cost of electricity. Our last power account over 71 days was $5,900 and at this rate was costing us $17/ha to apply 70 mm of water.

CONCLUSIONS

* Irrigation development requires a high capital outlay, and puts the cropping farmer into a high-cost farming enterprise.
* Average crop yields can be high even on light soils.
* There is individual satisfaction in consistently producing satisfactory cropping results and stock performance.
* There is financial gain for the physical effort involved.
Recognising the potential of cropping on irrigated land.

D. K. Redmond, farmer, Kirwee.

Originally from Canterbury we went down south in 1974 and purchased a sheep property of 111 ha at Kennington, 14 km from Invercargill, where my wife and I formed a farming partnership. The reason we decided to go south was economic, as we couldn't afford land up here, and land was relatively cheap down there at the time.

The property was semi-developed, and we developed 50 per cent with drainage and re-grassing before returning to Canterbury four years ago.

In 1979, we purchased our present property at Kirwee: 172 ha, running 1,400 Corriedale ewes and with 7 ha of crops. The soil type is Chertsey shallow-silt loam and Lismore stony-silt loam; average rainfall is 755 mm a year.

FARMING PRACTICE BEFORE IRRIGATION

We practised controlled grazing in the winter, using electric fencing, weighing sheep and measuring the amount of feed until lambing. Ewes were shed-off once a day, and made up mobs of 450 ewes and lambs, which were moved on to a rotational-grazing cycle after tailing.

Additional ewe lambs were brought in for replacements, as only half the
Corriedale breeding ewes were mated with Border-Leicester rams and the balance was Down-Cross, so that a larger number of fat lambs would be off the property before the end of December. The fertiliser programme was 100 t of lime annually and 250 kg/ha of superphosphate, while 29 ha of crops were grown for pasture renewals.

The stocking rate in 1980-81 (a year before irrigation) was 1,800 breeding ewes and 300 ewe hoggets, with a lambing percentage of 107 per cent.

Crops grown were:

- 7 ha of wheat yielding 2.47 t/ha
- 12 ha of barley 3 t/ha
- 10 ha of peas 1.5 t/ha, and
- 7 ha of clover 150 kg/ha (machine-dressed)

This returned a gross income of $450/ha.

We increased sheep numbers to the limit to keep up with rising costs; this placed us in a very vulnerable position in seasons of drought, and the crop yields under dryland conditions were not economic.

**CROPPING POTENTIAL UNDER IRRIGATION**

My wife and I decided to proceed with irrigation because of the drought seasons, to increase our income to keep up with inflation, and take advantage of the attractive interest rates available from the Rural Bank.

The capital cost of irrigation was high because of the depth required to reach water, but good results were being obtained by farmers with cropping systems in the area so we decided to reduce stock numbers and increase the area of crops to get a higher gross return.

**IRRIGATION DEVELOPMENT**

The well was drilled in June 1982 to a depth of 120 m with a static water level of 75 m and a test flow of 60.5 l/sec. The farm was developed with underground ring mains, for the entire property, for two B100 Turborain irrigators.

Initially, we had one Turborain, which could cover 5 ha/day in a 23-hour run, but with downtime, caused by shifting between paddocks, and lower irrigation efficiency caused by high winds, irrigation scheduling was falling behind.

Under the new Rural Bank Irrigation Policy we were able to purchase a second irrigation system, which made being in the right place at the right time much easier. Now instead of applying 75 mm gross on 5 ha a day, we put on 50 mm gross on 10 ha.

To get a suitable run length, some internal fences had to be moved and a small amount of fencing done with paddock sizes ranging from 10 ha — 20 ha.

No shelter belts had to be taken out (more by good luck than good management). Additional shelter will be planted for the north-westerly winds that Canterbury enjoys.

Total development cost of the irrigation was $1120/ha. Sixteen hundred of the breeding ewes were retained and 2700 store lambs were brought in during December and February with 55 ha of crop undersown with white
clover, and 34 ha of small seeds which consisted of: 12.95 ha of wheat yielding 6.94 t/ha; 30.36 ha barley, 6.25 t/ha; 11.33 ha peas, 4.60 t/ha; 10.12 ha grass seed (machine-dressed), 948 kg/ha; 24.29 ha white clover, 765 kg/ha (field-dressed).

This returned a gross income of $1300/ha.

A budget was drawn up before our application to the Rural Bank. We achieved that quite comfortably, which has made us very confident that we made the right decision.

The good yields from clover this season were because of these being second-year paddocks, as we had anticipated having irrigation.

In the coming year we will increase our area of cropping to about 140 ha, as it has given us 12 months to improve our cash flow, storage facilities and plant. We will be reducing ewe numbers to about 500 and buying store stock after harvest to maintain fertility and use straw residue.

**IS IT PROFITABLE?**

Since being asked to present this paper, we decided to look at the profitability of irrigation, having felt all along that it was profitable.

With assistance from Ken Muscroft-Taylor, farm adviser with the Ministry of Agriculture and Fisheries at Darfield, we compared our first year’s development with the dryland base, and projected costs and returns for future years. The financial analysis was done on a micro-computer using the MAF Cash and Devpro Programme.

We found irrigation was very profitable in all years, with good benefits, even after repaying interest and capital on loans. In addition, the surplus, after living, taxation and capital, was better than the dryland base in all years. Taxation is likely to be our next problem.

**CONCLUSION**

After irrigating for one season, my wife and I have proved that irrigation is profitable, growing traditional crops such as wheat, barley, peas, ryegrass and white clover. Our aim now is to get maximum economic yields from these crops, but in the future we could look at specialised crops, if we see that extra returns could be made.
New Zealand agriculture has developed with a production bias. Generations of rural New Zealanders have been raised with the philosophy that if we can grow, then by continually improving production efficiency we will usually be able to sell. Now obviously, just because something can be grown in New Zealand is not sufficient reason for growing it. Even if something can be grown well, this should be grown only if clearly someone wants to buy, at a price at which we can profitably produce.

As a nation we must become more market oriented, and agriculture can be no exception. What New Zealand agriculturalists must do is to study consumer wants and needs, and decide from these what should be produced, rather than taking the traditional view of trying to dispose of what is being grown.

This is marketing a product compared with selling a commodity, and if marketing means producing a product, wanted by the market, when required by the market and at a price the market is prepared to pay, then we are all involved in marketing.

This is not a revolutionary concept and has been promoted by many, but, with the notable exception of the dairy industry, seems to have gained more ready acceptance in the manufacturing industry than in agriculture.
However, when a market-oriented approach is coupled with maximising our comparative advantages a possible future strategy for arable farming becomes clear.

NEW ZEALAND’S ARABLE RESOURCE

New Zealand has a rugged landform, and the 71 per cent of the land area too steep for cultivation obviously has lesser versatility than land which can be cultivated. Of the 29 per cent of our land area with terrain suitable for cultivation, only about one-third is considered to be of high actual or potential value for food production — that is slightly under 10 per cent of total land area. However, only about 17 per cent of this land of high value is presently being used for arable production, or about 2 per cent of the total land area. Although there is scope for significant expansion of the arable area, the relatively-small area of suitable land makes the careful consideration of arable options important.

New Zealand’s arable resource (arable land as percentage of all land) is relatively very limited compared with other developed countries, such as United Kingdom 28.7 per cent, U.S.A. 20.8 per cent, France 31.8 per cent, Denmark 62.4 per cent, Canada 4.8 per cent and Australia 5.6 per cent (F.A.O. Statistics 1979). Consequently, New Zealand must use this limited arable resource much more carefully, and must attempt to obtain maximum value.

In the long term, only in rare cases should land with potential for crop production be used for animal-based agriculture. Considering Canterbury, in particular, with extended irrigation complemented by increased shelter, then arable production will increase because higher returns will be necessary to cover higher costs. Clearly, however, any substantial expansion in arable cropping can only be aimed for export, since the domestic market is so small. If we are going to export then we must carefully consider our strengths.

COMPARATIVE ADVANTAGES

Sensible expansion of our arable industry will include those crops and systems in which we have a comparative advantage, provided these are those the market desires. Among the advantages New Zealand has are:

— an equable climate which allows good growth of most temperate species and generally allows good harvesting conditions.
— reversed seasons to the northern hemisphere.
— technologically-advanced farming with good expertise and efficiency.
— strong industry infrastructure for provision of seed, fertiliser, chemicals, seed cleaning, and so on.
— sophisticated research and development capacity in both public and private sectors.

In combination, these give relatively-low production costs, relatively-high yields, good quality and the capacity to change from one seed crop to another.
On the debit side are:
- our distance from the major population centres of the world.
- high off-farm costs.
- a level of complacency and inertia within all sectors of society.

**POTENTIAL PRODUCTS**

What kinds of products will maximise comparative advantage? One obvious criterion for export crops is to minimise that proportion of the final market price resulting from freight and processing costs. For example, the value of clover seed in a full container is much greater than the equivalent volume of wheat. Similarly, luxury products, such as fresh stone or pip fruit, can withstand freight costs.

The other way New Zealand can keep ahead in arable production is to be able to identify new market niches for specialty products and to change production systems to produce these quickly. For example, with bulk grain production New Zealand farmers could not, in the long term, export competitively with countries such as the U.S.A., Canada, or Australia because those countries have economies of scale. But, as with manufacturing industries, if the right choice of specialised product is made then New Zealand can successfully compete.

Increased arable crop production of herbage seeds and specialty cereals, has potential for South Island farmers.

There are large markets in Europe for seed of new white clover and grass cultivars. New Zealand should be making more effort to capture some of this market. In the 1982-83 Recommended List for Legumes in the United Kingdom there are four white clover cultivars listed, for which there is no certified seed available. Cultivars Donna, Menna and Nesta were first listed in 1977, and Aran was first listed in 1981. The list notes that "certified seed may not be available for some of these cultivars because of the special difficulties in white clover seed production."

Yet white clover grows like a weed in Canterbury, and one of the technical difficulties facing seed producers in New Zealand is the large bank of seed which has been built up in the soil. Surely this is a made-to-order market for New Zealand, and a worthy topic for the seed industry to research. The key to any expansion in the white clover, or any other herbage seed market, is the provision of cultivars that the Europeans want; probably these will not be the same cultivars that New Zealand pastoral farmers want.

Closer Economic Relations with Australia has been described by some as being the beginning of the end of the wheat industry in this country. However, with this change come opportunities. There are large populations on Australia’s east coast, and since our average wheat yield is about three times the Australian average we should be able to compete well, at least with specialty lines. Purple wheat for specialist wholemeal breads, durum wheats for pasta, and specialist biscuit wheats should all have potential and ensure a sound future for our wheat-growing industry — provided we adapt to the changing circumstances.
PLANT BREEDING AS A MARKETING TOOL

This leads to the contribution that plant breeding can make to the development of arable cropping. Traditionally, crop-plant breeders have tried to improve the general yield and quality of crops. There are two major ways in which plant breeders can assist in these market-oriented developments.

First, they can improve the adaptation of favoured genotypes so these can be grown in areas where these may not normally thrive. A good example in New Zealand of this is work currently being carried out by DSIR to improve the cool-temperature tolerance of maize and soyabeans. This has already resulted in the release of the soyabean cultivar Matara.

The second major way in which plant breeders can assist is to add an extra characteristic wanted by the market place. Improved colour in durum wheats would give a more yellow pasta; pro-anthocyanidin-free barley cultivars would produce beer which had no tendency to cloud. In both cases, this would give a more desirable product. There are numerous other examples.

CONCLUSION

I believe there is an appropriate recent example to demonstrate the effectiveness of this sort of philosophy. The South Island Barley Society recognised that the international market desired the malting barley Triumph and let contracts for this cultivar in the last season. I am sure this product made selling their recent shipment easier.

It is said by military historians that successful generals only fight battles they know that they can win, and, because of this, take extreme care in choosing their battleground. I am convinced that our arable industry is set for a successful and expanded future provided that we thoroughly research the market, understand what parts of the market we are most competitive in, and then, and only then, bring to bear all our technical expertise in production.
In specialist small-seed production in Canterbury, a realistic opportunity exists for many farmers in the region. Canterbury offers the best combination of soil types, climate, land contour and available water. Yates' research headquarters, along with those of other industry research headquarters, are based here for this very reason.

Only about 40 per cent of farmers harvesting crops at present are approaching the job professionally, and could be called specialists. Forty per cent is frighteningly low, and gives rise to concern for the high investment in land, irrigation, fertilisers, chemicals, and machinery. There should be concern, too, that what is a business venture should be treated so lightly.

Farming industry leaders should be pointing out to those in small-seed farming that failure to capitalise on the environment and on their investment is a failure to put New Zealand agriculture on a firmer footing.

As a background to our sincerity and belief that there is a strong future for small-seed production here, I should outline our philosophy, which is probably shared by our industrial friends.

Our company has been involved in plant breeding for more than three generations, but has maintained an extremely-low profile. There has been a well-defined dedication to plant breeding, with intimately-detailed objec-
tivity, for only the last eight years. This came from a study made of New Zealand's future in agriculture and horticulture. The conclusions reached from the study were that an excellent opportunity was offered throughout the world for the supply of small seeds.

Our place in the world marketing of seeds requires us to have a completely-integrated, relatively narrow-based research facility. This facility covers plant breeding, pathology, crop agronomy, and to these we must add the extension growing trials, and the adequate maintenance of foundation seed, etc.

All these are essential if we are to continue a planned path of development. The reasons for this I will give later.

I believe maximisation of research dollars will come from those crops which exploit New Zealand's natural advantages, climate and soil, and New Zealand skills in agriculture and horticulture.

Principally these are forage species, cereals, peas, and a small range of vegetables. Perhaps I should make a special slot for the use of seeds in human nutrition and medicaments. More specifically, onions, dill, coriander, phacelia, limnanthes, Japanese radish, Japanese mustard, Oenothera, Chinese mustard, Chinese cabbage, oil seed rapes, linseed, sullia, buckwheat, triticale, sunflowers and sorghum. Apart from the major species, this is opening up a range we are involved in at present, and that have a substantial growth potential.

For seed production purposes the majority of crops outlined are ideally suited to Canterbury, and because of this our research station is based here. The station operates on some 134 ha, and we are looking to lease a further 24 ha.

We believe the time is opportune in New Zealand for us to expand research for educational purposes. The areas outlined are combined with about 12 ha in the Pukekohe district of the North Island, and some 18 off-site stations, selected for specific purposes, throughout both the North and South Islands.

The reason we have chosen such a large area is to enable us to deal with the problems that specialist seed growers will face in relation to the increasing number of cropping opportunities that will become available. We must have readily at hand most of the answers to help them produce worthwhile seeds and a good seed yield per hectare.

In the last four years our area has trebled in production of seed. Under cultivation at present we have 10,530 ha, most of which is in Canterbury, in production of seed for seed purposes. On that land we have developed specialised knowledge, covering 40 species and 150 cultivars.

We can give our growers a solid background in crop husbandry. This requires not only the knowledge of how to produce a good crop, but also taking the plant beyond the vegetative stage into the reproductive stage. We believe this requires more specialised skills than many growers are currently prepared to recognise.

This joint effort between the industrialists in the farming business and the practical farmer must be recognised.

Traditionally Canterbury cropping, as with cropping in other areas of New Zealand, has been based predominantly on the commodity market. Most of what has been talked about today has been relative to that market.
This has been backed in recent years by the Government-guaranteed wheat scheme, and, as a consequence, there has been a persistent cry of the lack of economic return from each hectare.

We have been at the forefront in working to change this system, because we do not believe the current system to be tenable with today's high cost of operation and capital investment. It is not tenable to allow the vagaries of the market place to dictate a return that is not always commensurate with the investment, and, therefore, allows farming to be a gamble.

Our company has been accused, in some quarters, of unrealistically increasing the price of various seeds grown in New Zealand. However, we believe we have been realistic in engineering a return to the specialist seed grower commensurate with the New Zealand values of his land, efforts and skills, so that we now have a group of professional growers, regularly available and reliable in yield and quality of seed.

A lot of this has been outside Canterbury, but, more recently, our activities have come to the fore here, and maybe we will be accused again of being interlopers in the traditional market in addressing ourselves to the more professional grower, taking him away from commodities, and increasing his return in tune with realistic overseas prices, and to this end we address ourselves to the economic basic inputs required to retain a profit-related yield.

With a base of good specialist growers, I can speak for the industry here, we are becoming more confident, and more aggressive in soliciting business overseas. We no longer gratefully accept the multiplication contract at almost any price, and, in the past, so often failed in deliveries through lack of specialised crop research. We now only accept what we are confident of being able to grow, and we use small seed-production areas to assess the real value of the crop. Therefore, we are confident that we can argue for a fair and realistic price, deliver the goods, and build confidence with quality and purity, to the satisfaction, not only of the client, but also of the grower, and our own investment criteria.

Our industry is confident that more and more hectares of seed production will become available, consistent with our quality and reliability on delivery. This is the sort of assurance that allows for forward planning, security in investment, not only in land, but in irrigation, machinery and good crop husbandry, and obtaining in return for that investment—a realistic overseas dollar.

I think you should congratulate the DSIR on the approach taken, and the co-operation industry gets from that organisation. I doubt whether farmers, generally, appreciate the substantial progress that is being made, and that we will have a substantially-increased dollar return for each hectare for the benefits outlined in specialisation. Dr. Mike Dunbier, in his address preceding mine, encapsulated the same thoughts. We are researching the opportunities of the market so that there is a secure future for the person prepared to invest, and to do the job properly.

However, it would be stupid of us to have a rush of blood to the head, have a fantastic increase in hectares, and a complete collapse of the marketing system. Unlike some people, I believe our overseas marketers are doing a good job, in line with the ability of the seed-specialist farmers.
I do not believe that our overseas marketers have undersold, relative to the skills we have at this stage. I think that in the last two or three years there have been changes, and we are only just beginning to reap the benefits of the confidence that overseas buyers now place in us. We are only getting part of their total business, as they may not have been particularly happy with quality and delivery given in the past. However, I believe the situation has now changed dramatically, so there is the opportunity for those above the 40 per cent level who are prepared to take time to study the problems that seed production presents. They will certainly reap a reward.
Specialist cereal crop production

Colin McNally, general manager Zealandia Milling, Christchurch.

Both Zealandia Milling, which I represent, and the Timaru Milling Company, the concern of Geoff South for whom I am standing in, are concerned with specialist cereal crop production. Geoff and I, whether to our advantage or not, have similar thoughts on this.

In this specialist cereal-crop production Timaru Milling is involved with the durum wheats that are used to make pasta. Timaru Milling has been involved in making and marketing pasta products since the early 1940s, and this involvement has now become very extensive. The basic material for pasta is, naturally, wheat, and, in particular, wheat with the characteristics of hardness, translucent colour, from a white wheat preferably, and with high or strong protein content. Until 1973 the raw material was whatever wheat was available most suitable for pasta manufacture.

The wheats had been developed, for logical reasons, with bread-making in mind. Included in the varieties were Cross Seven and Aotea, to mention just two, and later Hilgendorf, which had reasonable hardness and protein levels but with the significant colour disadvantage of being red wheat.

There are lots of wheats showing up for the flour-milling industry bred from red wheats. However, in flour production we are not allowed to bleach, as is done overseas, to take care of any colour problems. We are not saying
that the only wheat to grow for flour milling should be white, but we would ask that consideration be given to the possibilities of breeding wheat for specialist uses.

Durum wheats are used traditionally throughout the world in pasta production because of the quality characteristics of hardness, translucency and protein. These are necessary for pasta production.

In 1973, Timaru Milling, in conjunction with DSIR, started a collaborative research programme with the following objectives:

1. To establish varieties economically suitable for the growing conditions of Mid and South Canterbury, also giving satisfactory yield returns to growers.

The basis of the idea was that these should be commercially viable within the area of those calling for the raw material.

2. To incorporate quality screening into a selection programme, bearing in mind customer, market and manufacturing requirements.

This must apply to all wheat crops, for various purposes, and with quality to match. There is now more concern about quality. The bakery industry is talking, and has been talking for many years, about being given better quality. The milling industry would like to do this but wants the parameters of quality clarified.

Timaru Milling now gets all pasta requirements totally from durum-type wheats. There is a dynamic crop development programme, incorporating breeding, selection, and research aimed at ensuring the durum wheat quality is best suited to all concerned.

This must be the basis for all milling crops of the future. Consumer demand or customer market sets the quality and pricing parameters; the manufacturers, millers and bakers relate closely to the cost of production and the need to be commercially viable. Also essential is that the varieties to be grown are commercially attractive to the grower. This must also be so for all parties, after establishing the needs of the various sectors.

In the durum wheat programme, Timaru Milling, as manufacturer and marketer, carries out quality assessment to a large degree. The DSIR is involved in breeding and selection. The involvement of these two parties culminated in the signing in December 1982 of a joint-breeding agreement covering durum wheats. The MAF also contributed significantly, in Mid and South Canterbury, with on-farm research, variety and management technique trials, covering rates, times of sowing, nitrogen addition, and so on. Again the area sown is close to the end user, mainly because of the freight cost problem.

The private plant breeder is also involved. In this case this was Plant Breeders (NZ) Ltd, which introduced and trialled a variety which currently supplies a significant proportion of durum wheat requirements.

In terms of specialist cereal crop production, what lessons can be learned? Number one would be market orientation. The durum wheat programme is, and will continue to be, market oriented.
These people know what they want, and it is essential to produce what they want. Both the domestic and export markets set the qualities required, given the environmental variations. These also set the quantity of wheat required, and the cost of the raw material, allowing the final product to be sold competitively.

An integrated approach means there are very significant advantages in the use of resources, economies and general commonsense. The example we have is the marketing, manufacturing and quality assessment unit at Timaru Milling. Quality assessment is included in breeding and research resources, and for that we have government departments and private companies. Very importantly, we have the grower maintaining close liaison directly and through merchant contacts.

Lastly, the enemy we all face is time. In the example I have given you the initial work to full commercial exploitation took 10 years (1973–83). The potential is there, but we desperately need much stronger marketing expertise.

In Wheat 82 we were pleased to be involved as Zealandia Milling, and we brought Timaru Milling in with us. We wanted to demonstrate what the miller is looking for. We wanted to show problems of grain storage, and infestation, which is nasty and expensive, and other aspects of the products grown for us. We were extremely pleased with the results we got from Wheat 82, and we sincerely hope to be involved again. We put to the farming community very relevant questions about some of our ideas and, also I must add, we got opinions on storage of grain and the future of the industry from the growers’ point of view. The few days we spent at Wheat 82 were worth their weight in gold.

Under present conditions and pressures for quality there must be more dialogue between the end users, such as bakers, pastry manufacturers, and the flour millers, the growers, the private breeders, government departments (Crop Research Division and Wheat Research Institute) and other parties involved. This must be done to advance these key industries, which, for too long, have maintained a very low profile.

In Australia recently there was a shortage of rye, and we had an enquiry about the possibility of our supplying Eastern Australia with material. Samples were sent, and the comment came back that this was a quality not seen before. How did we do it? Along with many others we had been involved in research, with merchants and others being of great assistance. The work on rye had come to fruition in three years, a big difference to the 10 years on pasta development.

Competition is a real problem, and freight costs are part of that problem. Australia was getting rye for $200/t delivered into store ex Canada. I cannot get it off the paddock for that. We might be looking at freight across the Tasman of $150–160/t. If Western Australia decided to send rye to the eastern states the freight cost for twice the distance is $36/t.

Competition is something we must keep strongly in mind. We have got the quality, there are no two ways about that. The potential is enormous, and we must look at all factors. Freight costs, unfortunately, are one of the major factors.

In closing, I would like to say that maintaining a low profile must change. Millers and bakers must say what they are on about. If a baker wants a
specific product, we are the people who make it. We tell you, the growers, and the people who actually breed the material, and we can all work well together. Sadly and unfortunately, dialogue is lacking at this point, but this is changing quite rapidly.

It will get to the stage, because of the call for quality, that the industry will make available what is required, instead of accepting what is available.
The herbage seed levy

G. B. Robertson, Chairman, Herbage Seed Subsection, Federated Farmers.

To explain why the Levy was instituted and what is to be done with it, we must look at the markets for our herbage seeds. This is very timely, because at this conference we have been hearing about the potential for greater production of crops under irrigation, and with herbage seeds being one of the alternative crops we had better think seriously about where the increased production is to be sold.

As we produce more seed than the New Zealand pastoral industry requires, and about half of our production is exported, the export market sets the price to the producer.

Let us then look at the history of our herbage seeds as an export commodity. Back in the 1920s and 1930s New Zealand made huge strides in grassland management. Part of the business of making two blades of grass grow where only the one grew before, was the breeding and certification of improved grasses and clovers.

New Zealand was among the world leaders in this field and our certified perennial ryegrass and white clover were recognised as being the best available. Naturally other countries, particularly Britain, looked to New Zealand to supply certified seeds as they used New Zealand techniques in improving their own grasslands. Not only did we have a ready market, but we had it to ourselves.
Unfortunately, we grew complacent. With the advent of Plant Breeders' Rights after the Second World War, European plant breeders began breeding for the British market. Their efforts in breeding were accompanied by vigorous sales campaigns that exploited the fact that these new cultivars were bred specifically to do well under British conditions.

As an industry, we still believed that our seed was the best and our certification scheme the greatest, and allowed the aggressive Dutch companies to dominate the British seed market. The result is we now supply little ryegrass to the United Kingdom, and our Huia white clover is still the most important white clover on the British market simply because it is cheap and readily available.

Of course, other markets have opened. Our merchants have methodically, and often successfully, tramped the world opening up contacts so that now our seed is sold in a great many other markets around the world.

However in all these markets we are still, just selling a commodity with little or no promotion. Certainly some attempts at promotion have been made, with a varying degree of success by our merchants. Thankful as we must be as farmers for what has been done, most merchants will admit their promotional efforts can only go part of the way and they are not promoting our seeds amongst consumers, but only with seed merchants.

The reason for this is that under a free market system there is no justification for a merchant to involve himself in general promotion in a particular market. He has no way of ensuring he will make the resultant sales, rather than his four, five or six competitors also selling New Zealand seeds in that market. A merchant's interests, quite rightly, lie in maximising sales opportunities on the day, and his shareholders will not take kindly to spending funds on promoting a market when there is no guarantee that any increase in sales will be to his direct advantage.

Such promotion must be co-ordinated and paid for by the total industry under an umbrella organisation representing that industry. We are all familiar with the activities of producer boards in meat, wool and dairy products, and of the Industry Promotion Committees now being formed in horticultural products and recently by the deer industry. It is to this latter group that the Herbage Seed industry belongs, where the whole industry, the producer and marketing merchants, jointly promote their product.

In a market as geographically diverse as ours, and with relatively-limited resources, we must, of course, ask ourselves if this is worthwhile, and where do we start.

I believe promotion most certainly will be worthwhile. If we are ever to move our product from simply being a commodity sold because of being cheap to one seen by consumers as a quality product commanding a premium price, then we must invest in promotion. Some promotion could pay immediate dividends.

For example, Grasslands Nui has proved to be a ryegrass that performs well in Tasmanian pastures and there are good prospects of making sales of our seed there.

However, Tasmanian seed growers have already tried to get permission from New Zealand to certify Nui grown in Tasmania. This request has been rejected; a decision very much in favour of the New Zealand seed producer who should have the opportunity to produce seed for that market.
Yet already our position is being jeopardized by a group of Tasmanian growers attempting their own imitation certification scheme to produce Nui ryegrass. Our task must now be not only to promote Nui to Tasmania, but encourage the use of properly-certified seed of New Zealand origin. While this would involve some cost, it need not be expensive; for example, we should see that properly-compiled technical information on the usefulness of Nui is written up in the Tasmanian farming press and circulated to farm advisers. Publicity should be given to the value of using properly-certified seed from New Zealand.

Another important marketing and promotional issue involves Grasslands Huia white clover; of the 5000–6000 t produced in New Zealand, about half is exported, making white clover easily our most important single seed export. It is important, also, because we are the major supplier of white clover seed on the international market, exporting about 3000 t each year.

White clover seed production has been one of the more dramatic advances in farm management in recent years. Yields have increased with the use of modern chemicals and better harvesting techniques. With greatly expanded areas of crop under new irrigation in Canterbury, coupled with the better yields now being achieved, we could see greatly increased quantities of white clover seed produced. If, for example, we had a 50 per cent or 3000 t increase in production, this would involve doubling our export seed, and there is just no way the market could absorb that much clover seed unless at prices unrealistically low to the producer. Also, the use of white clover is now declining around the world.

We need to face up to the situation and do something. In Europe, the use of white clover in a pasture that is to be topdressed with high rates of bag nitrogen is declining; the assumption is the clover will be smothered by the grass and not contribute to any nitrogen fixation. Yet research has shown that even where nitrogen is applied in excess of 300 kg/ha, clover can be useful in making pasture more palatable and digestible to livestock.

We need to make known technical information such as this, and emphasise the use of clover in less-intensive pastures where clover is still very useful as a source of nitrogen.

Another related issue is whether we are able and willing to produce a wider range of varieties of white clover, for a range of situations from intensive lowland grass to extensive hill country, both within New Zealand and for export. We have avoided this decision in the past being awed by the difficulties of changing varieties on country containing hard seed of Huia.

Yet other clover-producing countries manage to change varieties in a given paddock, and techniques are available enabling this to be done here, so that we could provide a wider range of white clover varieties to our customers.

So much for our traditional species of perennial ryegrass and white clover, but what about some of the new pasture species now available.

The last few years have seen some interesting new varieties released by the Grasslands Division (DSIR), not only among conventional species, but also species not previously used to any extent in New Zealand pastoral farming, such as prairie grass, lotus and tall fescue. These have produced some special marketing difficulties for seed producers. A new species initially attracts a great deal of attention from the seed industry, and seed
prices are high as people set themselves up to produce in commercial quantities. Once the initial euphoria is over, and a greatly increased supply of seed is on the market, the price will crash if a real demand has not been generated among farmers.

No manufacturer would release a new product in such a haphazard way without gearing promotional effort to match production capacity and the seed industry in the 1980s cannot afford to do so either.

A case in point is Matua prairie grass. Seed growers are only this year able to look with some relief at a diminished stockpile of seed — a stockpile that was left when the initial boom finished. This is a variety with genuine potential, both in New Zealand and overseas. In the United Kingdom, for example, Matua is performing very well in trials, with production as good as the best Italian ryegrasses but with the advantage of being a perennial.

Seed production in New Zealand is about to increase once more because the commercial instincts of a number of seed producers tell them Matua is about to become a winner again, but unless we do something about promoting the variety both here and overseas it will not become a winner.

As part of that promotion we need to make sure that potential customers understand how to handle the peculiar difficulties involved with sowing Matua, so that they are not put off by one bad experience in trying to get the seed down the spout of the drill.

Another interesting situation is with Maku lotus, where the same boom-to-bust situation took place. There is now a steady supply of seed coming on to the market, but as yet there is not the demand for Maku there should be with its undoubted quality as a legume in pastures in lower-fertility situations.

The time is right to set up a vigorous promotion effort within New Zealand to ensure that what is an undoubted resource for New Zealand pastoral farming is properly used.

All the promotional work I have been talking of will succeed only if all components in the industry, Grasslands Division of DSIR as breeders, seed producers and merchants work together. This is already happening. We are shortly to see the establishment of a New Zealand Seed Promotion Council to co-ordinate this promotion.

This Council will be implementing a variety of promotional activities; some expensive, such as conventional advertising, but others, such as technical promotion that will ensure that trial information and technical data is properly publicised, need not be. For some promotional efforts such as the Maku lotus or Matua prairie grass, growers of these seeds will be invited to introduce a special levy to ensure these are properly established on the market, while for others the overall levy will be sufficient. In any case, the size of the growers' levy will be firmly in the hands of seed growers through the Herbage Seed Growers Subsection of Federated Farmers, and growers' funds will be used along with money already committed to promotion by merchants and Grasslands Division to enable an integrated and planned strategy of seeds promotion.

One special aspect of our promotion will be the adoption of a trade mark for the New Zealand Seed Industry to assist in the presentation of New Zealand seeds as a quality product. The New Zealand Agricultural Merchants
are already well on the way with the design of what will be a New Zealand Seed mark.

All of us involved in the seed industry, farmers, breeders and marketers may be late starters in the business of co-ordinated industry-wide promotion. Such promotion will not necessarily return immediate dividends, but to see the enthusiasm shown by the DSIR and merchants in getting something done as a total industry is very heartening. You can be assured that as seed producers you will be hearing a great deal more about Seed Industry Promotion.
The introduction of irrigation into large areas of New Zealand, particularly the drier areas of the East Coast of the South Island, such as Canterbury, will bring major changes in land ownership patterns, the agriculture practised and crops grown.

**IRRIGATION AND INTENSIFIED LAND USE**

Availability of irrigation water is the most potent form of technology available to agriculture to modify the environment. The use of irrigation in deserts of the world is obvious, but even in less-arid areas the sophisticated use of irrigation can be used to improve the reliability and performance of traditional crops and modify the non-rainfall components of the environment in such a way that crops normally considered marginal for a locality could be grown economically. I refer here to the direct use of irrigation water for frost control, high temperature modification, and temporary raising of atmospheric humidity essential for a number of important crops during critical periods of growth. Irrigation can be used indirectly to modify the effects of wind by ensuring rapid establishment and maintenance of desirable wind-shelter plant types.
HORTICULTURAL CROPS

Irrigation is the key to the introduction of intensive crop production normally included under the heading of horticulture. In the South Island, this is fruit tree crops, such as apples, pears (European and Asian), peaches, nectarines, apricots, cherries, plums, astringent persimmons, grapes (wine and fresh dessert), berries, such as strawberries, raspberries, boysenberries, black and red currants, blueberries, vegetables such as asparagus, onions, garlic, potatoes, tomatoes, broccoli, brussels sprouts, peas, beans, cabbages, pumpkins and squash and a wide range of fresh and processing herbs, nut tree crops and flowers.

My objective today is not to suggest which of these crops should be grown; this depends on many factors, not the least the availability of profitable markets. However, I have included these to illustrate the potential irrigation has to broaden considerably the range of crops which could be grown, compared to the traditional dominance of wheat, barley, oats, white clover and grass at present grown on the better soils of the Canterbury Plains.

Whenever irrigation has been introduced throughout the world it inevitably leads to more intensive agricultural land use, of which horticultural crops are important. I have no reason to believe New Zealand would be any different in the long-term, although a transitional period would occur. Economic and social pressures, which the availability of irrigation creates, will ensure this happens. The transition could be socially and economically painful, both for those wishing to retain a way of life associated with the traditional forms of farming, and those embarking on the learning curve associated with the introduction of the less-familiar crops of intensive agriculture. This not only applies to the producers, but would affect the traditional servicing industries, such as farm consultants and advisers, stock and station firms, machinery and equipment suppliers, financial institutions, and political affiliations and associations.

LESSONS TO BE LEARNT

While I am extremely optimistic about the future of horticulture in Canterbury and wish to see this province obtain its share of the horticultural developments, which in New Zealand have grown at a compound rate of 20 per cent a year over the last 10 years, I am concerned that the present recession in traditional farming may on the one hand create unreal expectations in some that horticulture may provide a short-term solution to their problems, and on the other hand lead to policies, particularly those involving water allocation rights, which will in the long term impede the orderly development of intensive cropping.

The long lead time required and the high capital and development costs associated with many horticultural crops, which at present have good prospects, need a dedication and long-term commitment which will not provide short-term relief from the present down-turn in pastoral or traditional mixed-crop farming.

The comparative lateness of Canterbury to enter into horticultural development, so evident in the North Island, does give us the opportunity to examine the options available for such development before these begin. There
are many good lessons to be learnt from horticultural development in the north, but there are also some disturbing features which we might avoid by careful planning.

The basis of the present horticultural boom rests on three crops, kiwifruit, apples and onions. Even worse, this depends largely on only three cultivars, Hayward for kiwifruit, Granny Smith for apples, and Pukekohe Longkeeper for onions. The almost complete faith in the kiwifruit as the goose which will continue to lay the golden egg, or should I say the brown-green furry egg, into the indefinite future is very disturbing to those closely involved with future development of horticulture in New Zealand. No industry should blind itself to the fact that every product, no matter how novel or innovative, has an economic life cycle, which early in life exists in a seller's market with resulting high prices, but, in time, faces a buyer's market when production levels meet or exceed demand and has to exist at a much lower level of return. This need not be bad, as the apple industry has shown in recent years.

This reliance on one crop, at present still a very attractive proposition, has lead to two features of some concern.

1. High prices people are prepared to pay for land labelled "horticultural potential" effectively capitalizes a substantial part of future earnings into the purchase price often before it has even been established whether the markets, the land or skills available, are capable of producing a crop economically.

2. The high price of the land and high cost of developing a productive orchard, combined with the expected continuation of the present high prices of some crops, has lead to an excessive subdivision mentality. In many areas land, which in the national interest is also capable of showing good returns with other horticultural crops or forms of agriculture provided units are large enough, is being subdivided into two to eight-hectare titles. The continued viability of these small holdings will depend very much on continued high returns. In the long term, if, for example, the price of kiwifruit falls, what is now an economic unit will be inadequate in size. Either another crop or land use of comparable return to the present kiwifruit will have to be found, or the severe economic and social disruption associated with amalgamation into larger kiwifruit holdings or into larger economic units for some other agriculture will occur. We have seen the economic and social distortions resulting from the lack of options of small holdings in Europe and Asia. The prospects of an agricultural peasantry in New Zealand is not something I would like to promote, nor do I believe it is a necessary consequence of the introduction of intensive agriculture such as horticulture.

**UNIQUE FEATURES OF CANTERBURY**

A unique feature of Canterbury, because of the historic dryland mixed pastoral-cereal cropping land use is the relatively large size, New Zealand standards, of farms. In addition, Canterbury is relatively flat, has substantial areas of good soil types suitable for many crops, and a relatively dry climate well-suited to mechanization. Combined with irrigation, Canterbury has the
potential to think horticulture on a larger property scale than is historically the case, or is being practised generally in the North Island. However, land ownership neither guarantees nor confers the ability, skills or dedication that intensive cropping requires. Even if these factors were combined successfully, the high developmental costs involved, and the debt servicing required can act as a strong deterrent, particularly where all the uncertainties associated with starting into a new form of agriculture exist. Often the traditional sources of finance available to existing farming are incapable or reluctant to lend sufficient capital long-term to unfamiliar ventures, even though future benefits which might accrue if successful are seen. More often than not, the funding available tends to allow a relatively small area of a new venture on any one farm backed by the security of the traditional farm use. This does not always encourage the type of long-term commitment or dedication required, or at a level required to allow economies of scale for efficient production. Horticulture, therefore, tends to be left to the newcomer who can often afford only a small holding, or who ties up so much capital in land purchase that there is little opportunity to develop the property fast enough to a viable level.

**LAND USE POLICIES**

Now is the time to formulate policies to set the pattern for future developments into intensive horticultural crop production in suitable areas of the South Island by:

1. Encouraging development of larger horticultural production units to provide more flexible land use options should the need arise.
2. Encouraging application of appropriate financial management and production expertise to such ventures.
3. Providing development funding of a scale or on terms appropriate to the long-term nature of many intensive crops.
4. Attempting to avoid the crippling escalation of land prices of much of the horticultural developments in the North Island, at least until production and market security for the products has been firmly established.
5. Encouraging orderly development of horticultural production initially in areas with the best chances of success because of climate, soils and infra-structure availability.

Some of these policy objectives could be achieved, particularly 4 and 5, if the size and locality of land suitable for intensive horticultural production could be identified as soon as possible. The identified existence of large areas of such land would certainly take some pressure off land prices if buyers understood that such land was not in short supply. Encouragement to develop the most suitable land first would certainly result if priority for water allocation could be focused on such areas.

**LAND OWNERSHIP AND OPTIONS**

Land ownership does not necessarily ensure competence in a new form of farming, nor a willingness to see such land used in the national interest. We must recognize that much of the land which may be highly suitable, may remain in the hands of owners who for very good personal reasons
do not wish to sell or take the risks associated with establishing a new form of agriculture with which they are unfamiliar.

Various approaches to this problem could be tried, from share-farming arrangements to leasing systems, which are used extensively in the United States. The leasing system has a number of advantages, not the least is separation of land ownership from production and management expertise. An opportunity would certainly be provided to allow development money to be focused towards the profitable production of the crop and go some way to eliminating the capital gains-type farming so characteristic of New Zealand farming, and horticulture in particular, in recent times. This certainly would help maintain the farm unit size, which in the national interest would not cut off options for future land use, and provide, at least, a period in which the viability of alternate forms of land use could be proved on a worthwhile scale, without burdening new early innovators with inflated land prices.

For this system to take effect, major changes in the attitudes to development funding by financial institutions may have to occur. Safeguards under law for both parties entering such arrangements may have to be examined, particularly when the long-term types of intensive crops are involved.

Finally, attitudes and preconceived ideas about the nature of many intensive crops will need to change in light of new technology. Marked progress is being made in demonstrating that not all tree crops need to be thought of in historic terms, that establishing an orchard means that your children or great-grandchildren will be the main beneficiaries. High plant-density systems being practised in New Zealand with stonefruit crops, offers the prospect of considering the profitable life-time of such enterprises as occurring within 10 years of planting.

Such technology I believe, will in the near future, become feasible with other crops traditionally considered to be very long-term.
Alternative bases for increased pip and stone fruit production in Canterbury

A. G. Malcolm, fruitgrower, and Canterbury director of the New Zealand Fruitgrowers' Federation.

Before discussing the increased production of pip and stone fruit, the relative economic health and viability of this fruit should first be examined.

**PIPFRUIT**

Pipfruit has been showing steady growth over the last 30 years, and there have been reasonable economic returns, with centralized exporting through the N.Z. Apple and Pear Marketing Board. There is now a worldwide possibility of some oversupply, but the outlook for new pipfruit orchards is good for well-run operations, although the degree of risk for the medium amount of skill required, is high.

Economic returns from pipfruit are relatively stable, but are not such that they can readily stand excess initial costs. The following points in land selection would help minimise establishment costs and increase returns.

Historically in Canterbury, fruit has been grown near the cities on high-priced land. In my opinion, the proximity to a city does not warrant the premium price.

Land should be: reasonably fertile; free draining; preferably on a slight
slope for frost drainage (frost protection should not be necessary on apples in Canterbury); at an increased altitude (100–200 m up has a great effect on improved fruit colour and type); not more than 20 miles from sea (frosts); preferably within 25 miles radius of Timaru Port, Lyttelton or Kaiapoi (freight costs), and sheltered from wind by land formation or trees.

**STONEFRUIT**

Stonefruit is presently entering a boom in production, and market trends at present are excellent. Returns from late nectarines appear to at least equal the profitability of kiwifruit. Exports are predicted to rise in value to $100 million by 1990. The outlook is excellent for the short and medium term, but the degree of risk is high, and the skill required is very high.

There are two main types of stonefruit development: intensive, with 1 m by 4 m, tree spacing, and semi-intensive, 4 m by 6 m tree spacing. For intensive plantings, because of the very-high establishment costs, high-priced drained land can be justified; for semi-intensive plantings, low-priced land is preferable.

Beneficial aspects are to have land that is facing north, preferably with a slope, adjacent to a river bed or gorge, and with frost protection. There should be free-draining sub-soil, and stones are an advantage, with shelter from land formation or trees. South Canterbury is preferable to North Canterbury, and inland rather than coastal to induce lateness of crop for a market slot and higher prices.

Profitable fruit production requires skill and expertise; suitable land and climate, and development capital of $10,000 to $20,000 a hectare. However these requirements are seldom found in one property. It is quite accepted for development finances to be sought if the land is already owned. Alternatively, leasing the land, or hiring the necessary expertise should be possible.

**LAND TENURE OPTIONS**

If the object is to make a profit by farming, instead of by capital gain on the land, leasing land and using what capital is available to plant and produce the crop makes economic sense, provided there is sufficient profit to justify the risk of capital.

The length of the lease available will dictate what fruit crops should be considered. Peaches and nectarines would require a lease of at least 10 years. Apples in Canterbury would require a lease of 15 to 20 years. Also, because an established apple orchard has a residue value at the end of 20 years, being able to sell the trees with the land is financially advantageous.

An advantage of leasing is that an opportunity is provided for an experienced person with limited capital to get into profitable fruit production, and acquire capital or a cash flow that will enable land purchase in the future.

The advantages for a person owning land leased for fruit production are:

* Potential returns from fruit growing justify a rent giving a return that favourably compares with results from other farming by the owner.
* Opportunities of testing a crop without risk to the owner if the crop is new to the district.
* Allowing a farmer without the necessary skills in fruit production to observe and assess potential.
* Involvement in fruit production without requiring development capital from the owner.
* Providing jobs in a country district at no cost to the owner.

CONCLUSION

Leasehold has definite advantages for both parties in peach and nectarine production, but is less attractive for apricots and cherries, apples and pears, unless a very long term is available.

The best alternative for these latter crops may well be for those with suitable land to join together in a group that can afford to purchase the required skill and expertise of a first-rate orchard manager.

The land need not all be adjoining, but would probably need to be in at least 8 ha lots. The manager’s job would be to plan and co-ordinate the planting and production of these crops, especially in the establishment years.

Planning and management would be done best by one person as a first-rate manager, to be paid about $20,000–$25,000 a year, rather than by an adviser separately, with a manager of lesser quality. Co-ordination would be better, there would be more incentive for success, and no buck passing.

There may be potential for company-type investment in fruitgrowing in Canterbury. The present budget provisions, however, make this less attractive than before.

The successful farmer of the future will need to consider all crops that could be grown profitably on his land. If he chooses fruit growing as one option, he will, I hope belong to both the New Zealand Federated Farmers and the New Zealand Fruitgrowers’ Federation.
INTRODUCTION

Continuing interest in intensification of land use in New Zealand has focused increasing attention on the potential of perennial horticultural crops. Lincoln College has been to the fore in developing and encouraging a mechanised production of crops, such as blackcurrants, on a farming scale, during the last decade. Before advocating planting tree crops such as peaches, nectarines, apples and pears looking back on the events of the last few years in order to re-establish some credibility is necessary.

The blackcurrant story has not been a happy one for some farmers, and already only two or three years after the establishment of large areas, they are being removed as unprofitable. Other blackcurrant growers are undergoing extreme cash flow problems, with high establishment and machinery costs being subject to interest payments on borrowed money at a time when full production should be providing adequate income to allow some capital repayment. Too many farmers appear to have rushed into production hoping for a lucrative "Kiwifruit of the South" bonanza. The increase in production of blackcurrants in New Zealand is, of course, chicken-feed in relation to world production, and New Zealand has little control over world price trends for what is predominantly a processing commodity. Fresh, dessert commodities, such as peaches and nectarines, may possibly influence...
prices on Northern Hemisphere markets out of season.

Blackcurrant growers may have to accept world price fluctuations and ride out the troughs by production efficiency. The trouble is that yields have varied from less than 1 t/ha, up to more than 10 t/ha, and the combined effect of low yield and low price has been crippling. Many low-yield areas provide important examples of farmers neglecting the exacting demands and skill required in growing horticultural crops well.

In spite of skilled production technique, there is no way that blackcurrant production can be profitable at prices below 55–60c/kg to the grower. Prices ruling recently below 40c/kg are quite unrealistic. Whether or not a blackcurrant marketing authority could have improved the situation by eliminating a multitude of weak sellers is questionable. Nevertheless, the price recession could have some positive results in forcing the blackcurrant industry to get its “marketing act” together and to encourage development of processed products, such as juice, dried or frozen products, of interest to the market.

I seriously question the reason why so few New Zealanders are drinking blackcurrant juice as a beverage. My family of four “can’t get enough of it” and consumes at least a flagon of ready-to-drink juice a week. Costing for a flagon indicates that it is cheaper than Coca Cola, Fanta or Leed, and, in the opinion of my family, more nutritious and acceptable as a beverage.

Home-made blackcurrant beverage:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (per flagon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6kg blackcurrants at $1</td>
<td>$0.60</td>
</tr>
<tr>
<td>0.25kg sugar at 72c</td>
<td>$0.18</td>
</tr>
<tr>
<td>Power</td>
<td>$0.10</td>
</tr>
<tr>
<td>Labour 10 min. at $5/hour</td>
<td>$0.83</td>
</tr>
<tr>
<td><strong>Total cost/flagon</strong></td>
<td><strong>$1.71</strong></td>
</tr>
</tbody>
</table>

One flagon per week = 31 kg fruit/year

If the industry could persuade between 50,000–100,000 New Zealand families to use about 30 kg of fruit a year in this way, the whole crop of blackcurrants would be consumed in New Zealand. Note that the price for the fruit is included at $1/kg, a more realistic figure than the present unprofitable price. The question I’m so often asked after people have sampled the drink is: “Where can I buy a bulk carton of blackcurrants”. Where indeed?

There is a lesson to be learnt from this story. Farmers will continue to plant an apparently-lucrative crop until some limitation prevents it from being as lucrative as an alternative crop. So very few blackcurrants and boysenberries are being planted, and blueberries are now the glamour crop. The process of supply and demand will create an equilibrium situation with this crop as well. Many predict a disastrous slump in the kiwifruit industry, considering the extent of recent plantings. There may be some slight recession in prices, but I am more optimistic than most that the industry will continue to be viable with the strong marketing base, which has been
intelligently established, and with an industry awareness well in advance of back-up resource requirements.

So to pip and stone fruit: the next "bandwagon" for South Island land developers. One million peach stones are being planted this 1983 winter in the South Island in preparation for budding selected varieties of peaches and nectarines in January and February 1984. Fresh export to Australia and the whole of the Pacific Basin shows such promise that we must take notice of the "killing" made by some lucky growers already into the peach and nectarine bonanza. There is a demand at present for late-season stone fruit which the South Island of New Zealand is capable of fulfilling, more so than most other fruitgrowing districts in the Southern Hemisphere. What potential volume this market can accept is not known. There lies the risk. It may be that I could be accused of being irresponsible in advising farmers to plant stonefruit, and encourage even more than one million stones to be planted next year. My advice is tempered with a warning that this bubble could also burst. The arithmetic must use conservative estimates of yield and price. The same warning was issued for blackcurrants 10 years ago. Remember, like blackcurrants, there is no sound marketing structure as yet for stonefruit. The capital input is high, the expertise needed is high, and the risks of frost, hail, wind, drought and disease must all be taken into account. But there is a chance to use our high value land more effectively, and Lincoln College has a responsibility to lead the way in modern techniques and realistic production and management method.

HOW TO USE THE LAND?

Apart from scientific endeavour for the sake of pure discovery, we must interpret the role of Lincoln College as being one of education, research and demonstration to allow the New Zealand farmer to compete with (or beat) farmers in other countries. It seems a sad commentary that, as a result of our endeavours to use our land efficiently, some other countries will be worse off and job opportunities will be lost. New Zealand cannot afford to support supplementary minimum price schemes (SMPs) other than in the short term. Subsidies on farm production cannot be advocated long term if there are other profitable ventures available. Current prices for good horticultural land are:

<table>
<thead>
<tr>
<th>Region</th>
<th>Price Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawkes Bay</td>
<td>$20,000–25,000/ha</td>
</tr>
<tr>
<td>Auck.-Whangarei-Keri Keri</td>
<td>$25,000–35,000/ha</td>
</tr>
<tr>
<td>Bay of Plenty</td>
<td>$40,000–50,000/ha</td>
</tr>
<tr>
<td>Canterbury</td>
<td>$5,000–12,500/ha</td>
</tr>
</tbody>
</table>

There is no way we can continue to produce sheep or even grain profitably on land of this value. Hawkes Bay orchardists are becoming aware that even orcharding may be marginal on land worth $25,000/ha (apart from kiwifruit), and are developing interest in South Island land. Why grow apples on $25,000/ha land when land available in the South Island at $10,000/ha will grow apples just as well?
Lincoln College has paid slightly more than $10,000/ha for 28.4 ha of fertile silt-loam soil near Prebbleton and intends to plant:

12 ha of stone fruit
8 ha of pip fruit
7 ha of other fruit

The other fruit includes astringent persimmons, Asian pears, and possibly even grapes and kiwifruit. To aid short-term cash flow, intensive crops, such as strawberries are likely to be used.

**CAPITAL REQUIREMENT**

Horticultural development is extremely capital intensive. Apart from the initial land cost, the following capital expenditure is estimated for the first six years for the 28 ha College orchard:

<table>
<thead>
<tr>
<th>Item</th>
<th>First Six Years Cost (Excluding Labour)</th>
<th>Cost (Including Labour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td>$196,000</td>
<td>($7,000/ha)</td>
</tr>
<tr>
<td>Buildings, equipment and roading</td>
<td>$210,500</td>
<td>($7,518/ha)</td>
</tr>
<tr>
<td>Trees</td>
<td>$113,250</td>
<td>($4,045/ha)</td>
</tr>
<tr>
<td>Tree supports</td>
<td>$52,500</td>
<td>($1,875/ha)</td>
</tr>
<tr>
<td>Regular labour</td>
<td>$173,250</td>
<td>($6,187/ha)</td>
</tr>
<tr>
<td>Total excluding labour</td>
<td>$572,250</td>
<td>($20,437/ha)</td>
</tr>
<tr>
<td>Total with labour</td>
<td>$745,500</td>
<td>($26,624/ha)</td>
</tr>
</tbody>
</table>

This will support an establishment profile as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Shelter</th>
<th>Irrigation</th>
<th>Annual Crops</th>
<th>1984 (Rods 6 ha)</th>
<th>1985 (Rods 6 ha)</th>
<th>1986 (Rods 8 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>Peaches</td>
<td>Nectarines</td>
<td>Strawberries</td>
<td>Peaches</td>
<td>Nectarines</td>
<td>Apples</td>
</tr>
<tr>
<td>1985</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Emphasis will be placed on varieties of stonefruit maturing during the February–April period, and on carefully selected red strains of apples, such as Cox Orange Pippin, Red Gala, Red Delicious, Braeburn and Fuji. There is no guarantee that astringent persimmons and Asian pears will be profitable crops, but market indications are favourable, and we know these will
grow and crop successfully in the South Island. Our objective with the new orchard is to take calculated risks to provide leadership, but to make decisions based on sound management principles. This will be a commercial venture using borrowed money and realistic investment criteria.

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenue (after harvesting)</th>
<th>Capital</th>
<th>Orchard costs (with labour)</th>
<th>Annual cash flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>-</td>
<td>111,750</td>
<td>10,400</td>
<td>-111,750</td>
</tr>
<tr>
<td>1984</td>
<td>-</td>
<td>16,500</td>
<td>24,350</td>
<td>-26,900</td>
</tr>
<tr>
<td>1985</td>
<td>-</td>
<td>202,100</td>
<td>226,450</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>27,800</td>
<td>116,800</td>
<td>48,900</td>
<td>-165,700</td>
</tr>
<tr>
<td>1987</td>
<td>81,000</td>
<td>73,100</td>
<td>59,800</td>
<td>-105,900</td>
</tr>
<tr>
<td>1988</td>
<td></td>
<td>52,000</td>
<td>64,900</td>
<td>-35,900</td>
</tr>
<tr>
<td>1989</td>
<td>142,392</td>
<td>2,000</td>
<td>74,800</td>
<td>+65,592</td>
</tr>
<tr>
<td>1990</td>
<td>223,003</td>
<td>2,000</td>
<td>89,900</td>
<td>+131,103</td>
</tr>
<tr>
<td>1991</td>
<td>260,573</td>
<td>2,000</td>
<td>97,600</td>
<td>+160,973</td>
</tr>
<tr>
<td>1992</td>
<td></td>
<td>2,000</td>
<td>110,500</td>
<td>+178,740</td>
</tr>
<tr>
<td>1993</td>
<td>322,916</td>
<td>2,000</td>
<td>117,500</td>
<td>+203,416</td>
</tr>
<tr>
<td>1994</td>
<td>334,116</td>
<td>2,000</td>
<td>117,500</td>
<td>+214,616</td>
</tr>
<tr>
<td>1995</td>
<td>345,316</td>
<td>2,000</td>
<td>117,500</td>
<td>+225,816</td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td>2,000</td>
<td>117,500</td>
<td>+237,016</td>
</tr>
</tbody>
</table>

**TABLE 1:** Annual estimates for Lincoln Springs Orchard.
Cash-flow estimates indicate a maximum accumulated loss situation by 1988 of $1 million (including the land price) and with annual cash flow becoming positive in 1989. Accumulated cash flow is estimated to become positive by 1995 (after 12 years). Critical factors in the estimates are yield and price. Summarised annual estimates are presented in Table 1. As an example stonefruit prices have been estimated at only $4/4 kg tray to the grower, compared with current prices almost double this figure. Estimates are based on 60 per cent export of stonefruit (with the remaining 40 per cent not marketed), a factor very important to take into account when estimating fresh export of horticultural crops. Conservative estimates have also been applied to pip fruit.

A computer programme has been developed to delineate price and yield factors about the mean, and apply an interest rate to the calculations. Present indications are the venture will return about 10 per cent on capital, not taking into account inflation. Although 10 per cent return on capital does not seem to be a strong investment prospect, this is considerably better than could be expected from traditionally farming the land at this value, unless of course SMPs are unwisely used to compensate the difference.

Unfortunately, perhaps, developers have been looking towards horticulture as a tax-saving venture. Until the 1982 Budget this was a valid and substantial tax-saving method for professional people with other income and money to invest. This has been a highly significant source of capital, and there is little doubt that horticultural production in New Zealand has developed rapidly as a result.

However, taxation saving (dare I say dodging) has become a way of life in New Zealand, and is uppermost in the minds of those formulating investment plans. Whatever the rights and wrongs of the new legislation limiting claims of development expenses to $10,000 per person each year, we must accept this with a positive and realistic attitude. Someone must pay the required taxation, and I suggest that we develop a new attitude of mind towards horticultural investment; namely return on capital, and make decisions accordingly.

PARTNERSHIPS, TAXATION AND INVESTMENT

Recently, a North Island organisation issued a prospectus for a 200-unit persimmon partnership, in which each partner would contribute nearly $30,000 in the first 4 years. Total investment would be about $5.75 million before the individual's tax savings reduced this to less than $3.5 million—a net tax saving of about $2.25 million. That even the new regulations permit this type of tax saving on horticultural development expenditure is a substantial form of government subsidy.

The $10,000 annual development—expense regulation limits the amount each partner can charge against taxation, so that the obvious way to increase interest in horticultural investment is to increase the number of partners. To many individuals this is objectionable. This type of legislation is claimed not to apply to any other industry, or form of development expenditure. An attempt has been made in Table 2 to apply realistic figures to the original cash flow calculations for the College orchard, incorporating a land rental of about $400/ha and total borrowing from the Rural Bank of
### TABLE 2: Property taxation assessment of the Lincoln Springs Orchard (assuming commercial ownership by five partners).

<table>
<thead>
<tr>
<th>Year</th>
<th>Calculated Cash Flow</th>
<th>Deduct Rental and Interest</th>
<th>New Cash Flow</th>
<th>Cash Loss/Profit</th>
<th>Depr. and Inv. All.</th>
<th>Taxable Loss/Profit</th>
<th>Accumulated Loss</th>
<th>Annual Loss/Profit/Partner</th>
<th>less $10,000 allowable</th>
<th>Accumulated allowable loss/partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>(111,750)</td>
<td>16,000</td>
<td>(127,750)</td>
<td>(100,000)</td>
<td>8,750</td>
<td>(108,750)</td>
<td>(108,750)</td>
<td>(21,750)</td>
<td>(11,750)</td>
<td>(11,750)</td>
</tr>
<tr>
<td>1984</td>
<td>(26,900)</td>
<td>16,000</td>
<td>(42,900)</td>
<td>(31,400)</td>
<td>4,425</td>
<td>(35,825)</td>
<td>(144,575)</td>
<td>(7,165)</td>
<td>2,835</td>
<td>8,915</td>
</tr>
<tr>
<td>1985</td>
<td>(226,450)</td>
<td>21,000</td>
<td>(247,450)</td>
<td>(101,450)</td>
<td>30,533</td>
<td>(131,983)</td>
<td>(276,558)</td>
<td>(26,397)</td>
<td>16,397</td>
<td>25,312</td>
</tr>
<tr>
<td>1986</td>
<td>(165,700)</td>
<td>21,000</td>
<td>(186,700)</td>
<td>(115,700)</td>
<td>24,398</td>
<td>(140,098)</td>
<td>(416,656)</td>
<td>(28,020)</td>
<td>18,020</td>
<td>43,332</td>
</tr>
<tr>
<td>1987</td>
<td>(105,900)</td>
<td>26,000</td>
<td>(131,900)</td>
<td>(104,900)</td>
<td>12,968</td>
<td>(117,868)</td>
<td>(534,524)</td>
<td>(23,574)</td>
<td>13,574</td>
<td>56,946</td>
</tr>
<tr>
<td>1988</td>
<td>(35,900)</td>
<td>26,000</td>
<td>(61,900)</td>
<td>(21,900)</td>
<td>28,396</td>
<td>(584,820)</td>
<td>(584,820)</td>
<td>(10,059)</td>
<td>(59)</td>
<td>56,965</td>
</tr>
</tbody>
</table>

### 1989-1995

<table>
<thead>
<tr>
<th>Year</th>
<th>Calculated Cash Flow</th>
<th>Deduct Rental and Interest</th>
<th>New Cash Flow</th>
<th>Cash Loss/Profit</th>
<th>Depr. and Inv. All.</th>
<th>Taxable Loss/Profit</th>
<th>Accumulated Loss</th>
<th>Annual Loss/Profit/Partner</th>
<th>less $10,000 allowable</th>
<th>Accumulated allowable loss/partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>65,592</td>
<td>26,000</td>
<td>39,592</td>
<td>37,592</td>
<td>15,055</td>
<td>22,537</td>
<td>(562,283)</td>
<td>(4,507)</td>
<td>(5,493)</td>
<td>(46,965)</td>
</tr>
<tr>
<td>1990</td>
<td>113,103</td>
<td>26,000</td>
<td>87,103</td>
<td>85,103</td>
<td>13,021</td>
<td>72,082</td>
<td>(490,201)</td>
<td>(14,416)</td>
<td>4,416*</td>
<td>36,965</td>
</tr>
<tr>
<td>1991</td>
<td>160,973</td>
<td>26,000</td>
<td>134,973</td>
<td>132,973</td>
<td>11,537</td>
<td>121,436</td>
<td>(368,765)</td>
<td>(24,287)</td>
<td>14,287*</td>
<td>(26,965)</td>
</tr>
<tr>
<td>1992</td>
<td>178,740</td>
<td>26,000</td>
<td>152,740</td>
<td>150,740</td>
<td>10,327</td>
<td>140,413</td>
<td>(228,352)</td>
<td>(28,083)</td>
<td>18,083*</td>
<td>(16,965)</td>
</tr>
<tr>
<td>1993</td>
<td>203,416</td>
<td>26,000</td>
<td>177,416</td>
<td>175,416</td>
<td>9,339</td>
<td>166,077</td>
<td>(62,275)</td>
<td>(33,215)</td>
<td>23,215*</td>
<td>(6,965)</td>
</tr>
<tr>
<td>1994</td>
<td>214,616</td>
<td>26,000</td>
<td>188,616</td>
<td>186,616</td>
<td>8,531</td>
<td>178,085</td>
<td>(115,810)</td>
<td>(35,617)</td>
<td>28,652*</td>
<td>—</td>
</tr>
<tr>
<td>1995</td>
<td>225,816</td>
<td>26,000</td>
<td>199,816</td>
<td>197,816</td>
<td>7,869</td>
<td>189,947</td>
<td>(305,577)</td>
<td>(37,989)</td>
<td>27,989*</td>
<td>—</td>
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</tbody>
</table>

* Taxable
FIGURE 1: Individual partners cash situation $ for five partners.

FIGURE 2: Accumulated cash input for each partner ($) for 5, 10 and 20 partners.
### PARTNERS' CASH SITUATION

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Loss/Profit</th>
<th>Capital Costs</th>
<th>Total Cash Requirement</th>
<th>Less Borrowed</th>
<th>Net Cash Requirement</th>
<th>Cash Input/Partner</th>
<th>Less Tax Saving</th>
<th>Real Cash Input/Partner</th>
<th>Accumulated Cash Input/Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>(100,000)</td>
<td>27,750</td>
<td>(127,750)</td>
<td>50,000</td>
<td>(77,750)</td>
<td>15,550</td>
<td>5,000</td>
<td>10,550</td>
<td>(10,550)</td>
</tr>
<tr>
<td>1984</td>
<td>(31,400)</td>
<td>11,500</td>
<td>(44,900)</td>
<td>-</td>
<td>(42,900)</td>
<td>8,580</td>
<td>5,000</td>
<td>3,580</td>
<td>(14,130)</td>
</tr>
<tr>
<td>1985</td>
<td>(101,450)</td>
<td>146,000</td>
<td>(247,450)</td>
<td>50,000</td>
<td>(197,450)</td>
<td>39,490</td>
<td>5,000</td>
<td>34,490</td>
<td>(48,620)</td>
</tr>
<tr>
<td>1986</td>
<td>(115,700)</td>
<td>71,000</td>
<td>(186,700)</td>
<td>-</td>
<td>(186,700)</td>
<td>37,340</td>
<td>5,000</td>
<td>32,340</td>
<td>(80,960)</td>
</tr>
<tr>
<td>1987</td>
<td>(104,900)</td>
<td>27,000</td>
<td>(131,900)</td>
<td>-</td>
<td>(61,900)</td>
<td>16,380</td>
<td>5,000</td>
<td>11,380</td>
<td>(92,340)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Loss/Profit</th>
<th>Capital Costs</th>
<th>Cash Requirement</th>
<th>Less Borrowed</th>
<th>Net Cash Requirement</th>
<th>Cash Input/Withdrawal</th>
<th>Less Tax Saving</th>
<th>Add Real Cash Input/Withdrawal/Partner</th>
<th>Tax Payment (60%)</th>
<th>After Tax Withdrawal</th>
<th>Net Acc. Cash Input/Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>(21,900)</td>
<td>40,000</td>
<td>(61,900)</td>
<td>-</td>
<td>(61,900)</td>
<td>12,380</td>
<td>5,000</td>
<td>7,380</td>
<td>(2,650)</td>
<td>13,971</td>
<td>(99,720)</td>
</tr>
<tr>
<td>1989</td>
<td>37,592</td>
<td>2,000</td>
<td>35,592</td>
<td>-</td>
<td>35,592</td>
<td>7,118</td>
<td>5,000</td>
<td>(12,118)</td>
<td>(8,572)</td>
<td>17,623</td>
<td>(87,602)</td>
</tr>
<tr>
<td>1990</td>
<td>85,103</td>
<td>2,000</td>
<td>83,103</td>
<td>-</td>
<td>83,103</td>
<td>(16,621)</td>
<td>5,000</td>
<td>(16,621)</td>
<td>(2,650)</td>
<td>18,898</td>
<td>(73,631)</td>
</tr>
<tr>
<td>1991</td>
<td>132,973</td>
<td>2,000</td>
<td>130,973</td>
<td>-</td>
<td>130,973</td>
<td>(26,195)</td>
<td>-</td>
<td>(26,195)</td>
<td>(8,572)</td>
<td>18,754</td>
<td>(56,008)</td>
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<tr>
<td>1992</td>
<td>150,740</td>
<td>2,000</td>
<td>148,740</td>
<td>-</td>
<td>148,740</td>
<td>(29,748)</td>
<td>-</td>
<td>(29,748)</td>
<td>(10,850)</td>
<td>20,754</td>
<td>(38,890)</td>
</tr>
<tr>
<td>1993</td>
<td>175,416</td>
<td>2,000</td>
<td>173,416</td>
<td>-</td>
<td>173,416</td>
<td>(34,683)</td>
<td>-</td>
<td>(34,683)</td>
<td>(13,929)</td>
<td>-</td>
<td>(18,136)</td>
</tr>
</tbody>
</table>

**TABLE 3:** Partners' estimated cash situation (assuming five partners) for the Lincoln Springs Orchard development.
$150,000. Depreciation and investment allowances have been calculated according to present legislation, and the allowable annual development loss applied, assuming five partners. Note that the loss allowable against taxation accumulates to a maximum of $56,965, and is subsequently applied to years 1989 — 1994 inclusive, in spite of taxation being payable from year 1990.

Not all expenditure is tax deductible. Buildings, machinery, equipment and trees for a new planting are considered to be capital, but irrigation, shelter, support structures and roading are development expenditure items.

Each individual partners cash situation is calculated in Table 3 and illustrated in Figure 1. Taxation saving is calculated at an average terminal tax rate of 50c in the dollar, but when the share of income becomes taxable in 1990 an average rate of 60c in the dollar will be applied. In individual circumstances these items would need to be adjusted.

Figure 2 illustrates the accumulated cash input pattern for each partner for 5, 10 and 20 partners.

CONCLUSIONS

Orchard crops have the potential to produce a reasonable return on capital on land, the price of which has become too high for traditional farming. The new taxation regulations, limiting deduction of annual development costs, means there must be careful planning of the cash input required from each partner. Although losses can be carried forward, the regulations tend to encourage larger partnerships. The provision that property must be owned for 10 years to avoid additional taxation places emphasis on development as well as on working a mature orchard. Intensification of land use is likely to increase the number of jobs available. The 28.4 ha Lincoln College orchard is likely to employ three full-time people, as well as about 2500 hrs/month of casual labour for three to four months of the year during harvesting. As the Apple & Pear Marketing Board is responsible for selling all pip fruit, some stability in the development of pip fruit plantings is provided. An industry based on the export of fresh stonefruit carries more potential market risk, but the rewards can be substantial.

Horticultural cropping is a risky business. The rewards can be high but frost, hail, wind and other unforeseen hazards can cause substantial losses. Management and husbandry skills are essential to produce the high quality required for export. The capital input needed is high with high debt servicing. A carefully established orchard, well maintained, is liable to provide a very good capital gain, as evidenced by farm land converted to kiwifruit production.

Those looking for a quick return from a small input should leave orcharding alone to avoid getting their fingers burnt. Those looking for a challenge, with some risk and prepared to do things well should try it. Land use in the South Island will be changing as it has further north.