SOME ASPECTS OF THE ECONOMICS OF NITROGEN STORAGE FARMING IN NEW ZEALAND

by

B. P. Philpott,
I. D. Greig
and
A. Wright

Agricultural Economics Research Unit Discussion Paper No. 22
Lincoln College, University of Canterbury, N.Z. May, 1972

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I. INTRODUCTION

In this paper we are concerned with some economic aspects of the use of artificial nitrogen fertilisers in New Zealand agriculture. With the prospect of much cheaper nitrogen fertiliser in the future (and possibly more expensive phosphatic fertiliser), some agriculturalists looking well to the future have suggested that New Zealand should and will move progressively towards systems of farming which are much more dependent than at present on nitrogenous fertilisers.

The most comprehensively argued approach comes from Dr K.J. Mitchell, Director of the Plant Physiology Division of the New Zealand Department of Scientific and Industrial Research. In a number of recent papers[14,15] he has argued that fertiliser nitrogen should be progressively substituted for clover as a source of nitrogen in New Zealand agriculture. Also, this should be coupled with a change in farming systems away from conventional clover based pasture towards continuous cropping and storage of maize and annual winter ryegrass.

Though we propose in the paper to touch on some of the wider aspects of nitrogen use, our attention will be concentrated mainly on Dr Mitchell's suggested system which is important enough to justify a preliminary economic appraisal.

In subjecting Dr Mitchell's proposals to a critical economic appraisal, we are not indulging in the negative criticism that is so often implied when criteria of profit and loss are applied to a new and important idea. Indeed, we started out with the contrary hope, namely that we would find increased profits or reduction in costs in the suggested new approach. At the least we felt that an economic appraisal of this sort would lay bare just where the economic advantages and disadvantages of the nitrogen-storage-system lay by comparison with conventional systems of producing livestock fodder. Also, in what directions further technical research should proceed if the maximum cost reductions or profit increases were to be achieved.

In tackling this subject we have laboured under two major disadvantages. The first concerns the fact that there does not exist a great volume of research data relating to the agronomy of nitrogen fertiliser in New Zealand, especially in relation to grassland. Thus we have had to fall back in many cases on the opinions and guesses of agricultural scientists with whom we have discussed the matter.

The second problem is that there is very little data available on costs of production of conventional pasture and, imperfect as our methods are, we found it necessary to tackle this question first, in order to provide a bench mark against which to compare the production costs of the new technology.

We proceed as follows:

In Section II we discuss the economics of conventional clover-based pasture production. This is followed in Section III by a brief description and case study of a Mitchell type farm, and in Section IV by an economic appraisal of both this and other types of farms. In Section V the original budgets are recalculated to give return to land rather than the conventional return to capital.

Some general criticisms are given in Section VI, followed in Section VII with a discussion of costs of feed conservation and storage of alternatives. Some alternative nitrogen using approaches are canvassed in Section VIII before the whole matter is summed up in the concluding Section IX.

II. THE ECONOMICS OF CLOVER BASED PASTURE PRODUCTION

There is very little[1] published information on costs of pasture production in New Zealand - a reflection possibly of the difficulties of estimating dry matter yields from pasture on commercial farms. A discussion of this matter is required before we turn to the specific question of estimating costs.

2.1 Estimating Dry Matter Production

There are a number of ways of estimating the production of dry matter on commercial farms in New Zealand, none of them really satisfactory or accurate enough for the required purposes. The method we have used is based on animal requirements and required us to work backwards from known levels of production of butterfat or meat per acre in different regions and for different types of farms. To these figures of output we applied the feed intake requirements variously estimated and published by animal nutritionists in dry matter terms. This gave an estimate of the lbs of dry matter utilised per acre given our knowledge of the animal output per acre.

The meat and dairy production data is taken from two major farm surveys in New Zealand, viz, the N.Z. Dairy Board Economic Survey[4] and N.Z. Meat and Wool Boards' Economic Service Sheep Farm Survey[5]. The former gives results on a

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[1] Mitchell & Kearton [15] give an estimate of costs of production of feed under grazing systems and with nitrogen storage farming but little detail underlying the grazing pasture calculations is given. Dr Mitchell (pers. comm.) provided the basis of their calculations, which gave a figure somewhat in excess of ours, mainly because of a higher interest rate used. However, we thought it necessary to carry out our own calculations for a wide range of regions and types of farms.

regional basis but unfortunately the latter is given only on a type of farming basis. The feed intake data are from Coop [6], Hutton [7], Wallace [8] and Jagusch [9].

As a check against this method we also compiled figures from two alternative approaches based on land output rather than animal requirements. Firstly we took the published [1] county figures of areas in various fodder crops, improved and unimproved pasture, etc., and applied to these figures our own guesses as to the utilised dry matter yields for each type of vegetation produced in each county. From these county figures we built up regional and national totals. A further alternative was based on the regional estimates of land areas in each of a number of soil productivity classes published by the New Zealand Soil Bureau [2], [3] and again applying to each soil type estimates of utilised dry matter production and aggregating for regions and for New Zealand.

We found not only reasonable conformity between the national totals for each of these two alternative "land output" approaches, but also between both of these approaches and the totals built up from the "animal requirements" approach for all New Zealand sheep farms and dairy farms. A reasonable degree of conformity however cannot disguise the fact that there is a high degree of uncertainty in all approaches though possibly somewhat less with the animal requirement approach which has been used in our estimates of costs of dry matter production.

2.2 Costs of Pasture Production

Our estimates of the costs of producing conventional pasture are calculated by combining the estimates of utilised dry matter per acre for different regional types of farms as above with the published financial information relating to the same farms [4, 5].

The main task in this exercise was to divide up farm expenditures into those relating specifically to the production of feed, as distinct from those expenditures concerned with the activity of transforming food into animal product - butterfat or meat as the case may be.

Such an allocation of expenditure is desirable because of the different nature of the two farming systems involved. In the storage farming approach there are two separate activities - firstly, producing higher yields of fodder and then storing and transporting it to the housed animal; whereas in the conventional grazed pasture system the harvesting is done by the grazing animal. For a valid cost comparison of the two systems we must,however difficult the approach may be, attempt to break up costs of the conventional farming system in the same way.

In some instances there is no problem in the allocation of expenses. Thus fertiliser expenditure is clearly a feed production expense and shearing costs are clearly related to animal production. But a large number of expenditure items are by their nature difficult to allocate in this way (e.g. labour costs). The allocation we have adopted is likely, however careful we have been, to be extremely arbitrary and this applies especially to the allocation of overheads. Nevertheless, the results show a degree of uniformity which is not discouraging and which give us some sort of basis for the costs of conventional pasture production against which to compare the similar cost break-up which we later perform for the nitrogen-grass-crop approach.

The results of the cost calculations are given in Tables I and II for dairy farms and sheep farms respectively.

In both cases we show first the estimated full cost, including interest, farmer's labour and management reward etc., (but divided into components of cash, labour and interest) of producing feed in cents per lb of dry matter utilised.

Secondly, we give the costs of butterfat production and meat production divided into the costs of producing the feed per lb of the respective product and the costs of producing the product.

This is compared in the bottom lines of the two tables, with receipts per lb of the product to give a measure of the true profit or loss per lb of meat or butterfat after full interest and management reward have been charged. At the price levels ruling in 1967 dairy farming appears to have been much more profitable than sheep farming.

One further point must be made. With both dairy farms and sheep farms there is more than one product produced, especially with sheep farms where wool is a most important ingredient in receipts. In theory this implies that we should carry out a further cost allocation between meat production and wool production (and similarly for the sideline products on dairy farms). But by comparison with the great difficulty we have already mentioned above of allocating expenditure to feed production and animal product production, such a further break-up by particular animal product would have been extremely arbitrary and we did not attempt it.

Instead the alternative has been adopted of allocating all production expenses to the main product - meat or butterfat. However, when calculating revenue we allowed the amount received from wool or from dairy sidelines as an additional item in receipts per lb of meat and per lb of butterfat.

As a check on the sheep farm costs we have available some South Island budgeted pasture costs [13] for intensive fattening farms. When interest and management reward is allowed for these yield an estimated cost of producing pasture of 0.45c lb - reasonably close to the 0.40c lb given for this type of farm in Table II.

TABLE I

ESTIMATED COSTS OF GRAZED DRY MATTER AND OF BUTTERFAT PRODUCED

NEW ZEALAND DAIRY FARMS 1966/67

		North-land	Central Auckland	South Auckland	Bay of Plenty	Central Plateau	Taranaki Westland Uplands	Welling-ton	Waira-rapa	Hawkes Bay East Coast	Nelson Marlb. West Coast	Canty. Otago South-land	Average for New Zealand
Average Area of Farm	acs	236	143	144	152	180	145	113	164	119	244	147	163
Estimated Total Utilised Dry Matter Produced	lb	635,040	630,720	901,530	816,130	782,460	824,580	646,920	811,350	665,280	565,920	539,190	773,550
Dry Matter Utilised per ac.	lb	2,691	4,410	6,261	5,896	4,347	5,687	5,724	4,947	5,590	2,319	3,667	4,745
Costs of Dry Matter Prod'n													
Cash Costs	c/lb DM	0.51	0.50	0.41	0.45	0.47	0.46	0.43	0.43	0.41	0.55	0.55	0.44
Labour		0.18	0.18	0.15	0.17	0.16	0.16	0.17	0.16	0.17	0.20	0.21	0.17
Interest		0.17	0.23	0.21	0.21	0.22	0.23	0.24	0.18	0.17	0.19	0.31	0.20
Total		0.86	0.91	0.77	0.83	0.85	0.86	0.84	0.78	0.75	0.94	1.07	0.81
Costs of Butterfat Prod'n c/lb													
Costs of Feed to Animal's mouth		23.19	24.31	20.79	22.41	22.95	23.22	22.68	21.06	20.25	25.38	28.89	21.87
Costs of Fat "Production"		19.40	18.01	16.19	16.39	17.45	17.67	17.49	16.66	17.80	20.38	21.69	17.50
Total Costs incl. Interest		42.59	42.31	36.98	38.80	40.40	40.89	40.17	37.45	38.05	45.76	50.58	39.37
Receipts per lb Butterfat c/lb													
From Fat		31.80	33.52	35.33	34.07	30.78	36.21	34.77	34.34	32.94	28.13	36.04	34.28
From Other		9.97	9.24	5.82	6.96	10.42	7.73	7.27	7.47	8.72	13.47	12.88	7.79
Total		41.77	42.76	41.15	41.03	41.20	43.94	42.04	41.81	41.66	41.60	48.92	42.07
Profit per lb Butterfat	c/lb	-0.82	-0.45	4.17	2.23	0.8	3.05	1.87	4.36	3.61	-4.16	-1.66	2.7

TABLE II

ESTIMATED COSTS OF GRAZED DRY MATTER AND OF MEAT PRODUCED

NEW ZEALAND SHEEP FARMS 1966/67

		North Island Fattening Farms	South Island Intensive Fattening Farms	South Island Extensive Fattening Farms	North Island Hill Country Farms	North Island Hard Hill Country Farms	South Island Hill Country Farms
Average Area of Farm	acres	407	357	840	797	1,889	3,730
Estimated Total Utilised Dry Matter from Grazing	lbs	2,893,790	2,389,440	3,416,480	4,083,270	6,505,840	4,579,760
Per acre Dry Matter Utilised	lbs	7,110	6,694	4,068	5,123	3,444	1,227
<u>Costs of Dry Matter Production</u> c/lb DM							
Cash Costs		0.14	0.18	0.18	0.11	0.11	0.14
Labour Costs		0.08	0.09	0.08	0.07	0.06	0.06
Interest		0.10	0.13	0.11	0.06	0.04	0.07
	Total	0.32	0.40	0.37	0.24	0.21	0.27
<u>Total Meat Production</u>		67,524	61,601	75,396	80,693	120,547	89,708
<u>Costs of Meat Products c/ lb Meat</u>							
Costs of Feed to Animals' mouths		13.7	15.5	16.6	12.1	11.6	13.7
Meat "Production" Costs		9.7	11.3	11.5	10.2	10.6	10.8
Total Costs (Incl. interest)		23.4	26.8	28.1	22.3	22.2	24.5
Receipts per lb Meat from Meat		11.9	11.6	11.7	11.2	11.0	11.2
from Wool & Other		8.7	12.0	13.2	9.0	8.2	11.9
	Total	20.6	23.6	24.9	20.2	19.2	23.1
<u>Profit per lb meat</u>		-2.8	-3.2	-3.2	-2.1	-3.0	-1.4

In general, dairy farm pasture costs are much greater (nearly double) than those of sheep farms. Partly this reflects the more intensive production conditions in dairy farming and its concentration on areas with very high fertiliser requirements such as Taranaki and Waikato. Also this reflects the difference in seasonal pasture requirements in lamb fattening where there is not the same need as in dairying to maintain pasture production throughout the summer.

It is evident too that costs of feed production are the major proportion of costs of production of both butterfat and meat and increases or reductions in costs of this item will have a dominant effect on overall profitability of the farm.

The next two tables, III and IV, give the same data in an alternative form, namely, total income and expenditure and rate of return on capital. In these two tables the expenditure figures do not include any interest or rent payments, but they do include an allowance for the labour and management return of the farmer. The surplus is therefore available as a return on the capital invested after allowing for all costs. Capital in both dairying and sheep farming is measured at current replacement value rather than historical cost.

By and large, dairying farming is seen to earn a rate of return higher than a market rate of 5 per cent[2] but sheep farmers were in most cases earning much less than this. Hence if, in effect, a full market rate of 5 per cent were charged or had to be paid on all capital invested, a loss would have ensued.

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[2] We assume here the market rate is 5 per cent.

TABLE III

INCOME, EXPENDITURE AND RETURN ON CAPITAL

CONVENTIONAL DAIRY FARMING BY REGION, 1966/67

Region		North Auckland	Central Auckland	South Auckland	Bay of Plenty	Central Plateau	Taranaki Western Uplands	Wellington	Wairarapa	Hawkes Bay East Coast	Nelson Marlb. West Coast	Canty. Otago South-land.	New Zealand Average
Area of farm(acs)		236	143	144	152	180	145	113	164	119	244	147	163
Cows carried (no.)		84	74	104	107	97	102	76	97	78	69	62	93
Labour units (no.)		1.44	1.37	1.65	1.72	1.51	1.68	1.32	1.55	1.35	1.38	1.38	1.56
Butterfat Prodn(lbs)		23,520	23,360	33,390	33,190	28,980	30,540	23,960	30,050	24,640	20,960	19,970	28,650
Capital Employed:													
Land & Bldgs	$	20,267	26,955	35,189	31,880	32,085	34,263	29,017	27,898	21,532	19,456	31,774	30,079
Plant	$	3,604	3,139	3,790	3,780	3,630	4,013	2,909	3,593	3,114	3,407	3,596	3,647
Stock	$	7,618	6,301	8,503	8,887	8,731	8,490	6,345	8,083	6,919	6,233	5,408	7,887
Total Capital	$	31,489	36,395	47,482	44,547	44,446	46,766	38,271	39,574	31,565	29,096	40,778	41,613
Gross Income		9,833	9,989	13,745	13,616	11,938	13,419	10,073	12,566	10,264	8,719	9,769	12,053
Expenditure:(excl. interest & rent)													
Feed Prodn) Feed Storage)	$	4,407	4,256	5,047	5,085	4,964	5,159	3,893	4,805	3,834	4,257	4,110	4,745
Butterfat Prodn	$	4,083	4,811	4,885	5,299	4,530	4,769	3,800	4,513	3,962	3,876	3,973	4,529
Total Expenditure	$	8,490	9,067	9,932	10,384	9,494	9,928	7,693	9,318	7,796	8,133	8,083	9,274
Surplus	$	1,343	922	3,813	3,232	2,444	3,491	2,380	3,248	2,468	586	1,686	2,779
Rate of Return on Capital	$	4.3	2.5	8.0	7.3	5.5	1.8	6.2	8.2	7.8	2.0	4.1	6.7

TABLE IV

INCOME EXPENDITURE AND RETURN ON CAPITAL

CONVENTIONAL SHEEP FARMING 1966/67 BY REGION

		North Island Fattening Farms	South Island Intensive Fattening Farms	South Island Extensive Fattening Farms	North Island Hill Country Farms	North Island Hard Hill Country Farms	South Island Hill Country Farms	South Island Mixed Farming
Area of Farm	acres	407	357	846	797	1,889	3,730	536
Stock Units carried	no.	2,209	1,824	2,608	3,117	4,964	3,496	1,302
Labour Units	no.	1.82	1.87	2.21	2.16	3.30	2.34	2.10
Meat Production	lbs.	67,524	61,601	75,396	80,693	120,547	89,708	41,333
Capital Employed								
Land & Buildings	$	64,835	64,198	77,344	55,318	62,716	68,279	70,248
Plant	$	2,423	4,483	7,159	2,117	2,806	4,146	6,745
Livestock	$	16,083	15,932	19,562	24,465	40,618	23,398	9,268
Total	$	83,341	84,613	104,065	81,900	106,140	95,823	86,261
Gross Income	$	13,896	14,535	18,796	16,283	23,168	20,755	19,925
Expenditure(excl. Interest & Rent)								
Feed Production) Feed Storage)	$	6,325	6,822	8,828	7,245	11,334	9,105	8,411
Animal Production	$	5,303	5,751	7,189	6,670	10,667	8,062	6,973
Total Expenditure		11,628	12,573	16,017	13,915	22,001	17,167	15,384
Surplus		2,268	1,962	2,779	2,368	1,167	3,588	4,541
Rate of Return on Capital		2.7	2.3	2.7	2.9	1.1	3.7	5.3

Source: N.Z. Meat & Wool Boards' Economic Service
Sheep Farm Survey

This analysis of rate of return on capital confirms the impression given by Tables I and II, namely that at the price levels ruling in 1967, dairy farming was much more profitable than sheep farming.

Finally we should mention here, since the matter will be raised again later, the costs of growing lucerne which is neither pasture nor crop. These also are derived from budgeted South Island figures [13] for a stand yielding 10,000 lb dry matter per acre and again allowing full interest and labour and management reward. The production cost is 0.32c lb dry matter. (The contract price to growers supplying the new dried lucerne factory is approximately 0.40c lb dry matter.) Costs of harvesting and storing lucerne as hay are dealt with later.

The costs given above are averages of districts or for the whole of New Zealand and they suffer from the disadvantages inherent in all such averages. We ought to be more interested in costs of the top producers to which level we might expect all producers to move over the next decade. It is not easy for dairy farms (and impossible for sheep farms) to find the exact data to establish costs of top producers but a reasonably accurate estimate, for dairy farms with butterfat production in excess of 400 lb per acre, is that costs per lb of dry matter utilised are 0.75c lb. This is not much lower than the Waikato or New Zealand average figures given in Table II.

III. THE STORAGE FARMING TECHNOLOGY

In this and the following section, we investigate, by means of a case study, the dry matter yields, fertiliser requirements, animal production and economics of feed production and utilisation under the approach suggested by Dr Mitchell in recent papers [14, 15]. This is based essentially on the concept of substituting fertiliser nitrogen for clover and substituting winter annual grasses and high yielding summer maize for permanent pasture.

The case study is a modified version of some recent work by McClatchy [16] on Silo Farming and the details and results relating to the farm are given in Appendix I. Here we give only a broad description.

The farm is a high producing Waikato farm of 110 acres on Soil Class 1A, capable of a grazing potential of up to 13,000 lb utilised dry matter and from this possibly able to produce in 10 to 15 years' time around 700-1000 lb of beef per acre from young cattle.

In place of grazing pasture it is assumed that the whole farm is used to produce summer maize for silage and that Tama winter ryegrass is cut, stored and fed as haylage.

The fodder is used to produce beef since this product seems the most likely to enjoy a reasonably favourable market in the future. It may be unwise to assume that increased dairy products could be sold.

The beef is produced in feedlots from approximately 1200 cattle, each fattened for 120 days, over which period they gain $2\frac{1}{2}$ lbs per day liveweight from a starting liveweight of 900 lbs to a finished liveweight of 1200 lbs.[3]

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[3] In the original silo investigation by D. McClatchy, only one batch of 400 cattle was fattened over the winter in order to earn a spring price-premium. No such premiums are introduced in the present study, for apart from the fact that it is assumed cattle are fattened throughout the whole year, we wish to concentrate our attention solely on the economics of beef production *per se* and free of any complications arising from special marketing situations.

The feed requirements and fattening rates are much the same as in McClatchy [16] and are based on data from Coop [6], Hutton [7], Jagusch [9] and Coop [10]. In spite of the paucity of New Zealand data on beef growth rates we assume the figures we have used are reasonably accurate.

No such assurance can be given however for the assumptions on dry matter production and the fertiliser requirements to achieve it, especially nitrogen requirements. Some New Zealand data relating to grass yields is available. No substantial data is available on maize yields under continuous cropping with nitrogen. The figures used were based on scraps of information from a number of published papers, correspondence and interviews with agronomists throughout New Zealand.[4]

The yields of maize and Tama ryegrass assumed by Mitchell in [14] were as follows:

<u>Maize</u> - 190 bushels per acre equivalent crop providing 22,000 lb dry matter per acre silage into store.

<u>Tama Ryegrass Winter Spring</u>
14,000 lb dry matter per acre into store.

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[4] In particular we cite the following publications: Mitchell [12, 14, 15], Broughan [11], During [17], Elliot [18], Walker [19], Williams [20], Ball [21], O'Connor [22], Committee on Grassland Utilisation [24], Vartha [25], Edmond [26], Scott [27]; and we acknowledge assistance given by Professors R.H.M. Langer, T.W. Walker, K.F. O'Connor, Dr J.G.H. White, Messrs G.A.G. Frengley and E. Cutler, all of Lincoln College; and D.J.G. Davies, I.L. Elliott, R.S. Gibbs, and D.B. Edmond. We acknowledge gratefully the assistance given by all these persons; naturally none of them can be held responsible for our views.

Great doubt was expressed by many people as to whether these yields - especially the maize yields - were realistic even with the fertiliser programme envisaged. However all critics had to admit that these doubts, or their own idea of yields, were not based on experimental evidence. In the absence of such evidence we have assumed that these yields are achieved in the present analysis. The fertiliser requirements, after allowing for nutrients in the dung and urine returned to the soil are as follows:

	Maize	Grass lbs	Total
N	135	300	435
P	25	30	55
K	150	270	420

These rates are based largely on various authors' estimates of N, P and K content per lb of dry matter in maize and grass respectively.

The total feed supply, after allowing for wastage, in the form of maize and silage and grass, amounts to 3,020,000 lb dry matter made up of 1,914,000 maize silage and 1,106,000 grass haylage. With this 1173 cattle are fattened producing 222,870 lbs carcase weight of beef.

By way of summary we have therefore the following results from the 110 acres with figures for conventional grazed clover pasture at its maximum potential for comparison:

	Nitrogen Farming per acre	Grazed Clover Pasture (at maximum potential) per acre
Dry Matter available	30,200 lb	13,000 lb
Beef Produced	2,229 lb	700 lb
Fertiliser Used		
N	435 lb	-
P	55 lb	55 lb
K	420 lb	140 lb

A large increase in beef production can be achieved as the result of using 435 lb Nitrogen (approximately one ton of sulphate of ammonia) and three times the amount of potash. But it is necessary again to point out that the increase in beef production of at least 1500 lb, depends very much on the high yields assumed. Were we to assume the maize yields which some critics (with substantiation) claim to be more realistic, the increase in beef production would only be of the order of 350 lb or so. Furthermore, the cost of getting this increase in beef production must be investigated and the relative profitability of the operation established. To this we now turn.

IV. THE ECONOMICS OF STORAGE FARMING

4.1 A 110 acre Beef Farm

Appendix I, giving full details of the 110 acre case study farm, contains the accounting facts which are merely summarised here in a form which facilitates comparison with the data given before on costs of dry matter production for conventional dairy and sheep farms.

First, in Table V we give a summary of the accounts with expenditures divided as in Tables III and IV, leading to the measure of rate of return on capital. For comparative purposes the results from Tables III and IV for South Auckland farms and for North Island Fattening Farms are repeated in the same table.

TABLE V

Income, Expenditure and Return on Capital

Nitrogen Farming and Selected Conventional Farms

		Case Study Farm	South Auckland Dairy Farms	North Island Fattening Farms
Area of Farm	acs	110	144	407
Butterfat Production	lb	-	33,390	-
Meat Production	lb	222,890	-	67,524
Capital Employed	$	226,515	47,482	83,341
Gross Income	$	45,960	13,745	13,896
Expenditure (excl. Interest & Rent)				
Feed Production	$	15,396	5,047	6,325
Feed Storage	$	12,274	-	-
Animal Production	$	12,660	4,885	5,303
Total Expenditure				
Surplus	$	5,630	3,813	2,268
Rate of Return on Capital	%	2.5	8.0	2.7

The rate of return on capital at 2.5% must be rated most unattractive and unlikely to lead to rapid or even slow adoption of this new technology. Further, the capital requirements are enormous - upwards of a quarter of a million dollars on 110 acres and this must operate as a further deterrent.

The budgets given above have been calculated at present prices for nitrogen and other fertilisers. But a fall in nitrogen prices even to as low as 3 cents lb, would not make a significant difference to the results - specifically, expenses would fall and profits rise by $3,045 and rate of return on capital rise to 3.9%, still too low to generate much excitement.

A more effective comparison between the conventional and the nitrogen system of farming is provided by the foregoing figures expressed per lb of dry matter and per lb of product produced as already presented in Tables I and II. This comparison is given in Table VI on the following page.

TABLE VI

Costs of Feed and Meat & Dairy Production
Under Nitrogen and Conventional Farming

	Nitrogen Case Study Farm	South Auckland Dairy Farms	North Island Fattening Farms
Utilised Dry Matter per acre lbs	30,200	6,261	7,110
		c/lb Dry Matter	
(1) Costs of Feed Production			
Growing Feed	0.60	0.77	0.32
Harvesting & Storage	0.57	-	-
Total Costs	1.17	0.77	0.32
(2) Costs of Animal Production		c/lb of Meat or Butterfat	
Feed Production	8.17	20.79	13.7
Feed Harvest & Storage	7.67	-	-
Animal Production Costs	7.34	16.19	9.7
Total Costs	23.18	36.98	23.4
Receipts per lb Animal Production	20.62	41.15	20.6
Profit per lb Animal Prod'n.	-2.56	4.17	-2.8

Note: All costs include interest on total capital at 5% and full allowance for owner's labour and management reward.

The results of this analysis show that:

(i) The costs of growing feed are lower than conventional Waikato dairy farms with which the programme is most comparable.

(ii) The costs of harvesting and storage of the feed are almost equal to costs of producing it. Hence total cost of feed at point of availability to animals amounting to 1.17 c/lb is about 0.4 c/lb higher than on dairy grazing farms and 0.8 c/lb higher than on fattening sheep farms.

(iii) The quality of fattening food produced and the efficiency with which it is fed mean that, by comparison with conventional fattening farms, there has been a reduction of 5.2 c/lb of meat in feed costs and 2.4 c/lb meat in meat production costs. These reductions are together just sufficient to offset the harvesting and storage costs and make total costs and losses per lb of meat about the same in both cases.

4.2 A 501 acre Beef Farm

In an attempt to investigate whether there are economies of scale arising from the spreading of capital costs over a larger area, we have budgeted the results for a 510 acre farm with exactly the same system as the foregoing 110 acre example.

Appendix II gives full details of this imaginary farm and of its operations. Here we simply give as before a summary of the results. Difficulties involved in securing the data for the 110 acre example which were grave enough, were greatly compounded when we turned to the 510 acre case. For example, we are, amongst other things, now confronted with the effluent problem from nearly

6000 animals and there are considerable problems of timing in the preparation of seed beds, sowing of grass and corn, etc., when dealing with so large an area.

The results must therefore be regarded with great caution. Certainly it would be fantasy to carry the exercise further and examine even larger sized farms.

However, with this caveat in mind we present as before in Tables VII and VIII below the summarised income statement and cost statement for the 510 acre example with the results from the previous 110 acre example given for comparison.

TABLE VII

Income, Expenditure & Return on Capital for 510 acre & 110 acre Storage Farms

		110 acre Case Study Farm	510 acre Case Study Farm	510 acre Case Study Farm (Premium Beef Margin) (1)
Meat Production	lb	222,890	1,071,900	1,071,900
Capital Employed	$	226,515	1,011,630	1,011,630
Gross Income	$	45,960	226,800	284,700
Expenditure (excl. Interest & Rent)				
Feed Production	$	15,396	64,330	64,330
Feed Storage	$	12,274	42,825	42,825
Animal Production	$	12,660	58,125	58,125
Total Expenditure	$	40,330	165,280	165,280
Surplus	$	5,630	61,520	119,420
Rate of Return on Capital	%	2.5	6.1	11.8

(1) Margin increased from $40 to $50 per head.

TABLE VIII

Costs of Feed & Meat Production
for 510 acre & 110 acre Storage Farms

	110 acre Case study Farm	510 acre Case Study Farm	510 acre Case Study Farm (Premium Beef Margin) (1)
Utilised Dry Matter per acre lbs	30,210	30,200	30,200
Costs of Feed Production	c/lb of Dry Matter		
Growing Feed	0.60	0.52	0.52
Harvesting & Storage	0.57	0.42	0.42
Total Costs	1.17	0.94	0.94
Costs of Animal Production	c/lb of Beef		
Feed Production	8.17	7.33	7.33
Feed Harvest & Store	7.67	5.92	5.92
Animal Production	7.34	6.95	6.95
Total Costs	23.18	20.20	20.20
Receipts per lb Meat	20.62	21.16	26.60
Profit per lb	-2.56	0.96	6.4

(1) Margin increased from \$40 to \$50 per beast

We note the following points from the above analyses relating to the 510 acre farm.

(i) Compared with the 110 acre case, the costs of feed production fall by 0.23 c/lb and the costs of beef production by about 3 c/lb so that a net loss of 2.58 c/lb is turned into a small profit of 0.96 c/lb.

(ii) Similarly the rate of return on capital rises from 2.5% to 6.1%.

(iii) The costs of growing feed at 0.52 c are now much lower than the costs of conventional dairy farms (0.97c) and even when harvesting and storage are included (giving 0.94 c/lb) the costs are now ~~not~~ much higher than the dairy costs.

(iv) These reductions in cost stem from the fact that the increase in some items of capital equipment on 510 acre farms is not as great as the increase in the size of the enterprise.

4.3 <u>The Influence of Higher Margins for Premium Beef</u>

Also given in Tables VII and VIII are the rate of return on capital and the cost calculations for 510 acre nitrogen storage farms producing beef but enjoying a superior selling price. This could be on account of higher quality beef (corn fed compared with grass fed), or by catching out-of-season premiums, or by superior marketing ability.

The margin increase allowed is $10, i.e. whereas in other beef budgets we assumed a purchase price of $80 and a selling price of $120 we now assume a selling price of $130.

This has a marked effect on the profitability of the enterprise with the rate of return on capital lifted to 11.8% (7.6% on a 110 acre farm). The cost of production of beef is, of course, unchanged at 20.2 c/lb but the receipts per lb rise from 21.16 c to 26.60 c, so yielding a profit per lb of 6.4 c.

While this is a rather more attractive rate of return than previously, we must remember that it is by no means certain that we can secure this premium. If we do, either on the local market or on export markets, the quantity of such beef which can be sold may fall far short of the quantities required to justify large scale adoption of the nitrogen storage technology.

One further general point needs to be made here. If a large number of beef fatteners went into the nitrogen storage farm quality beef fattening operation and did secure premium prices, there would be, as always happens, a tendency for the purchase price of store cattle to rise and the fattener's margin would disappear and accrue to the breeder. Investigations we have carried out show that (as with sheep breeding and fattening) cattle breeding on silo farms is quite uneconomic and it would be necessary for a nitrogen storage farmer or farm company to purchase a hill country or dairy farm breeding activity and integrate it with his fattening business.

4.4 Factory Supply Dairy Farms

In this section we present the results of some budget calculations for factory supply dairy farms. Although we hold the view that beef presents the most attractive long term marketing possibilities compared with other products, the known superior profitability of butterfat (at present prices and markets) makes it desirable to extend our attention to factory supply dairy farms.

Detailed case study budgets, for nitrogen storage farms producing butterfat for factory supply, are presented in Appendices III and IV - covering 110 acre and 510 acre farms respectively. Here we give only summarised results and these are presented in Tables IX and X. In these tables we have included, for the purposes of comparison, the results of the earlier studies of conventional grazing farms and nitrogen storage beef farms.

The rate of return on capital varies of course with the price assumed for butterfat. In the summary Table IX we have assumed a price of 35 c/lb for butterfat, approximately the same as that which was earned in 1966/67 by the Waikato pasture based farms. The variation in rate of return resulting from alternative price assumptions for butterfat is as follows:-

Prices of Butterfat	110 acre	510 acre
	Rate of Return on Capital	
25c/lb	-2.4%	0.6%
30c/lb	0.6%	4.0%
35c/lb	3.6%	7.4%
40c/lb	6.6%	10.8%

The rate of return is very sensitive to the product price used but only at 40c/lb does it approach levels comparable to the 8% earned in conventional dairy farming (and that only on the large 510 acre farm). In the present and projected state of dairy markets we could regard 40c/lb as a quite unrealistic price to use - indeed 35c/lb itself may be far too optimistic. Nevertheless it appears that the return on larger scale nitrogen storage farms producing butterfat is more satisfactory than with

TABLE IX

Income, Expenditure & Return on Capital Nitrogen Storage Farming
(with conventional Pasture Dairy Farm for Comparison)

			Nitrogen Storage Farming				
		Waikato Pasture Based Dairy Farm	110 acre Dairy (2)	510 acre Dairy (2)	110 acre Beef (1)	510 acre Beef	510 acre Beef Farm with Premium Beef Margins (3)
Area of Farm	acres	144	110	510	110	510	510
Butterfat or Meat Production	lbs	33,390	116,200	581,000	222,890	1,071,900	1,071,900
Capital Employed	$	47,482	192,755	849,850	226,515	1,011,630	1,011,630
Gross Income	$	13,745	40,870	204,350	45,960	226,800	284,700
Expenditure (excl. Interest & Rent)							
Feed Production	$	5,047	14,145	64,520	15,396	64,330	64,330
Feed Storage	$	-	11,824	44,065	12,274	42,825	42,825
Animal Production	$	4,885	7,958	32,976	12,660	58,125	58,125
Total Expenditure	$	9,932	33,927	141,561	40,330	165,280	165,280
Surplus	$	3,813	6,943	62,789	5,630	61,520	119,420
Rate of Return on Capital	%	8.0	3.6	7.4	2.5	6.1	11.8

(1) As in Original Report
(2) Butterfat at 35c/lb
(3) Margin increased from $40 to $50 per beast.

TABLE X

Costs of Feed & Meat & Dairy Production
(Conventional Dairy & Meat Farms & Nitrogen Storage Farms)

		Waikato Dairy	North Island Fattening Lambs	110 acre Dairy (2)	510 acre Dairy (2)	110 acre Beef	510 acre Beef	510 acre Beef with Premium Beef Margin
Utilised Dry Matter per acre	lbs	6,261	7,110	30,200	30,200	30,200	30,200	30,200
(1) Costs of Feed Prod. per lb D.M.								
Growing Feed	c/lb	0.77	0.32	0.55	0.51	0.60	0.52	0.52
Harvesting & Storage	c/lb	-	-	0.54	0.41	0.57	0.42	0.42
Total Costs	c/lb	0.77	0.32	1.09	0.92	1.17	0.94	0.94
(1) Costs of Animal Prod. per lb meat or dairy								
Feed Prod.	c.	20.79	13.7	14.34	13.12	8.17	7.33	7.33
Feed Harvest & Storage	c.	-	-	14.07	10.81	7.67	5.92	5.92
Animal Prod.	c.	16.19	9.7	9.08	7.74	7.34	6.95	6.95
Total Costs	c/lb	36.98	23.4	37.49	31.67	23.18	20.20	20.20
(2) Receipts per lb Meat or Fat	c.	41.15	20.6	35.17	35.17	20.62	21.16	26.60
Profit per lb Meat or Fat	c.	4.17	-2.8	-2.32	3.50	-2.56	0.96	6.4

(1) Costs include interest on total capital at 5% and full allowance for owner's labour and management reward.
(2) Price of Butterfat 35c/lb - income includes "other" farm income from livestock etc.

beef production (thus justifying the suggestion which led us to look at this alternative). If dairy markets improve markedly the whole approach could be economically feasible.

This point is more obvious when we look at the second summary table (Table X) which gives results for an analysis of costs of production firstly of feed and secondly of butterfat and meat.

To highlight the comparison the following is the comparison of costs of production per lb of butterfat on a conventional Waikato grazing farm and a 510 acre nitrogen storage butterfat farm.

	Conventional Farm	Nitrogen Storage
	c/lb Butterfat	
Costs of Producing Feed	20.79	13.12
Costs of Feed Storing & Delivery Feed	-	10.18
Costs of Animal Production	16.17	7.74
	36.98	31.67

The costs per lb for a 110 acre farm are 37.49 c. as shown in Table X.

A cost reduction of about 5c/lb has been secured by comparison with conventional dairy farming and even more compared with 110 acre nitrogen storage farms. The earlier suggestion that there were cost reductions from increasing the scale of operation for beef is here confirmed for dairying.

As with beef the cost reduction is the result of three influences. Much lower food production costs under nitrogen storage; offset by the high costs of food storage and delivery; but again a greatly reduced cost of animal production through greater control over fodder use and the efficiency with which it is transformed into butterfat.

4.5 Lamb Fattening

As a further alternative product, we analysed the returns from a nitrogen storage farm producing and selling fat lambs. The budget for this type of enterprise is not given, partly because of the paucity of information in production coefficients etc., and partly because it was obvious fairly early in the analysis that the returns from such an enterprise were going to be very unattractive. In fact the rate of return on capital is negative (-2.4%). This is largely because the lamb fattening operation even on the intensive scale envisaged here does not produce anywhere near the same amount of meat per acre as beef fattening. Lamb meat produced per acre is only 194 lb whereas the beef enterprises envisaged over 2000 lb. This reduction is no doubt due to the fact that a proportion of the food available is required for maintenance of breeding ewes throughout the years, and to this extent the comparison is unfair to sheep production because all the beef budgets considered involved running only bought-in fattening stock and no breeders. In fact an analysis of a self contained beef breeding and fattening silos unit also gave, as with lamb fattening, a negative return.

While New Zealand still has available expanses of cheap range type land suitable for store stock breeding, it is far more economic that breeding stock be produced in this way and certainly not with high cost storage farming techniques.

4.6 Tentative Conclusions

The tentative conclusions we reach from these budgets are:-

(i) For the 110 acre beef farm the return on capital is no higher than conventional fat lamb farming and not as high as conventional dairying.

(ii) For the 510 acre beef farm a more attractive return is earned, but this is still only a shade higher than the normal market rate of interest. Also it is far lower than what could be expected from improvements (especially higher stocking) in conventional farming where marginal returns to be expected are from 10% to 20% on added capital.

(iii) The amount of capital required is very high for the 110 acre farm and for the 510 acre farm the amount, at nearly $1 million is astronomical.

(iv) Reasonably attractive returns from nitrogen storage farming are possible from factory supply dairy farms at quite high butterfat prices; or from beef farms with premium beef prices. While special isolated cases where such prices will be relevant can be envisaged, we doubt that for either product there would be enough of them to conceive of general or large scale adoption of the new technology.

(v) Clearly if it were not for the very high costs of harvesting and storage under the nitrogen-fertiliser system, its profitability would be greatly enhanced. Still this is the economic penalty paid for adopting higher yielding forage plants like maize which cannot be grazed *in situ.*

In later sections we discuss in greater detail this question of the high costs of harvesting and storage of fodder crops and the economic disadvantages they bring.

4.7 Postscript

A recently completed study by Greig [35] lends support to the conclusions drawn above. Greig used a systems simulation approach[6] to study a proposed intensive feed cropping and beef feedlots unit. In brief, Greig found that for reasonably optimistic assumptions a return on capital of only 3.2% was achieved. The results are summarised below.

Area of Farm	acs	127
Meat Production	lb	299,310
Capital Employed	$	254,350
Gross Income	$	45,217
Total Expenditure	$	37,153
Surplus	$	8,063
Rate of Return on Capital	%	3.2

As a result of sensitivity analysis Greig concluded that beef prices are probably the greatest determinant of system profit. In particular he noted that:

> "Small changes in either the margin between purchase and sale or the general schedule level can offset quite large changes in other variables, even though schedule movements tend to be offset by changes in the margin. The implication for management is that the most direct way of improving profit would be to obtain a relative advantage in beef prices...."

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[6] The feature of the systems simulation approach is that it allows the system to be studied in much greater detail than is possible using relatively simple budgets. It also facilitates the process of testing the sensitivity of system performance to changes in key variables and relationships.

The Australian Bureau of Agricultural Economics recently completed a study of store cattle fattening in dry lot feeding [36] which contains the following conclusions.

"(1) At present feed and beef prices, fattening of store cattle by dry lot feeding in Australia is profitable only under very special circumstances.... including purchase and sale of cattle .... tuned to take the maximum advantage of seasonal movements in beef prices.

(2) .... if a feed lot is operated the whole year round, net returns are likely to be negative under average beef prices and management."

V. NET RETURN TO LAND VERSUS RATE OF RETURN ON CAPITAL

In all the analyses so far presented the criterion adopted has been the rate of return on all money capital invested in the storage farm. For a number of reasons it is desirable to supplement this with calculations showing net return per acre of land. In the first place there is no assurance that the value of land which we have used in the earlier analyses is the equilibrium or time value. Furthermore, should the final outcome of Britain's entry into the E. E. C., as far as the long term future of butter prices, be disadvantageous, then dairy land prices could be expected to fall below present value, all other things equal. A further consideration which has been mentioned is that by concentrating dairying on a very small area with storage farming, land could be released for other uses. Any exploration of this possibility (which, however, certainly cannot be carried out here) requires us to think in terms of land returns rather than capital returns.

Accordingly we present the calculations of Table XI which is divided into dairy farms and meat producing farms respectively. In each case the first two columns give the calculations of net return to land per acre, firstly for the conventional grazing farm and secondly for the 510 acre nitrogen storage farm.

The second two columns in each case give the same information in the form of costs and receipts per lb of butterfat and meat respectively.

The capital figures used represent all capital other than land and non-building improvements to land. The expenditure figures include no interest charge but do include an allowance for owner's labour and management reward.

TABLE XI

Net Return to Land and Cost of Production excluding Interest on Land

		DAIRYING					BEEF			
		Net Return to Land		Costs of Production per lb butterfat			Net Return to Land		Costs of Production per lb Meat	
		Waikato Grazing 144 ac.	Storage Farm 510 ac. (b)	Waikato Grazing 144 ac.	Storage Farm 510 ac.		Waikato Fat Lamb Farm 407 ac.	Storage Farm 510 ac.	Waikato Fat Lamb Farm 407 ac.	Storage Farm 510 ac.
				c/lb Butterfat					c/lb Beef	
Butterfat Prod'n	lb	33,390	581,000			Meat Prod'n lb	67,524	1,071,900		
Butterfat Prod'n per ac.	lb	232	1,139			Meat Prod'n per ac. lb	166	2,102		
Capital employed excl. Land & Improvements	$	22,189	674,850				31,506	836,630		
Gross Income	$	13,745	204,350	41.10	35.17		13,896	226,800	20.55	21.15
Expenditure: (a)										
Feed Prod'n	$	5,047	64,520	15.11	11.10		6,325	64,330	9.36	6.00
Feed Storage	$	-	44,065	-	7.58		-	42,825	-	4.00
Fat Prod'n	$	4,885	32,976	14.63	5.68		5,303	58,125	7.85	5.42
Total	$	9.932	141,561	29.74	24.36		11,628	165,280	17.21	15.42
Surplus	$	3,813	62,789	11.36	10.81		2,268	61,520	3.34	5.73
Interest on Non Land Capital	$	1,264	33,742	3.78	5.81		1,575	41,832	2.33	3.90
Surplus to Land	$	2,549	29,047	7.58	5.00		693	19,688	1.01	1.83
Land Surplus per acre	$	17.7	57.0	17.70	57.00		1.7	38.6	1.70	38.6

(a) Excluding all interest but includes management reward.
(b) Butterfat at 35c/lb.

From the surplus, interest on non-land capital (as defined above) is deducted giving the net return on land which is then expressed per acre.

In both cases the net returns per acre rise markedly on the 510 acre storage farm compared with the conventional grazing operation. Dairy farming (which it should be noted is calculated at the optimistic price figure of 35 c/lb butterfat) is still the highest producer per acre. However the proportionate increase compared with conventional farming is greatest with meat production.

This is in the line with the relative changes in the rates of return on capital already presented. Conventional dairying yielded 8% on all capital, storage farm dairying fell slightly to 7.4%. But storage meat farming yielded 6.1% which is far in excess of the 2.7% earned in conventional grazing farms.

The cost of production figures show that while there is some change in the surplus earned per lb of product the major contributing factor to increased returns per acre is much greater output per acre secured through the high concentration of capital per acre.

Which measure is correct - return on capital or on land? The answer depends on which is going to be the scarcest and therefore the most expensive factor of production in New Zealand - land or capital. If land were getting scarcer and higher in price then maximising returns from land by intensification implied by storage farming is appropriate. But if, as we believe more likely, there are agricultural marketing problems associated with the U.K./E.E.C. complex then New Zealand's shortage will be in capital not land - indeed our problem will be to reduce intensity of land use. Note the present attack on the dairy problem of trying to encourage farm amalgamation and larger farms.

If this is the case not only should we pause before using maximum returns per acre as a criterion, but we should perhaps take note that the interest rate used in the above analysis is 5%, probably far too low as a competitive borrowing rate for such a venture. If we used say, $7\frac{1}{2}\%$ then the surplus to land would be very greatly reduced and may even disappear.

Returning finally to the question of optimum land use which first prompted this analysis, it would be desirable to solve this question by setting up a large scale linear programming model incorporating alternative technologies and products given restrictions expected in markets. We would use the sort of information we now have on inputs and outputs to solve for that pattern of land use which made the maximum contribution to New Zealand national income. Such an analysis would be feasible if it were desired.

VI. SOME FURTHER CRITICISMS OF STORAGE FARMING

We list here further qualifications and criticisms of the use of nitrogen fertilisers and storage farming. These must be taken into account in appraising its future. Undoubtedly many of these problems will be solved by research over the next decade but until they are, the problems remain as deterrents to rapid adoption of the new system and it is only for this reason that we list them. Some have already been mentioned but are repeated here for completeness.

(i) Doubts as to the achievement, even with high fertiliser rates, of the necessary maize yields.

(ii) Ignorance of the fertiliser responses of maize and winter ryegrass under continuous cropping.

(iii) Possible deleterious effects of continuous cropping on soil structure. Need for superbly efficient effluent return and ignorance as to the extent it substitutes for grazing animal.

(iv) Ignorance as to available maize areas - we need the climate of Gisborne and the topography of Canterbury.

(v) The conflict in the timing of the sowing of Tama ryegrass and the harvesting of corn. This implies that in many cases and areas, it would be more satisfactory to grow and harvest grain which can be harvested much earlier than corn.

(vi) Special climatic requirements for nitrogen fertilising - hot and moist, and the possible lack of response in drought conditions compared with clover.

(vii) Leaf producing systems have much greater power of resistance to, and recovery from, adverse climatic influences than crop systems.

(viii) Dependence of fodder supplies on maize production exposes farm to grave risks should there be crop failure compared with the grass system.

(ix) The low cost grass system is more flexible and provides greater manoeuvreability in periods of low farm prices or other adverse economic conditions.

(x) The corn/silage system by definition implies that all farms adopting it must grow their own maize. Apart from limiting the operation to certain land areas it does not allow the same advantages of specialisation inherent in some farmers growing grass and some growing grain or other easily stored or transported fodder.

(xi) The high capital cost, low returns and high harvesting and storage costs compared with grazing systems.

This last point now merits further consideration, given in the next section.

VII. THE COSTS OF FEED STORAGE AND CONSERVATION

The critically high level of costs of fodder storage and conservation under the nitrogen system suggests we should look at alternatives and especially (if we take note of point (v) in Section VI) the alternative implied by storing fodder in the form of harvested grain.

In this Section we briefly compare costs of alternative types of stored feeds with those established for the nitrogen system.

Firstly we can consider costs of conservation by traditional means such as hay or pit silage and also newer methods such as vacuum grass silage preserved in polythene wraps. When full allowance is made for the cost of farmer's labour, interest and depreciation on equipment etc., the costs of these operations are surprisingly high. We estimate[7] the cost of making hay, storing and feeding out as 0.48 c/lb of dry matter and for vacuum silage 0.50 c/lb - these compare with 0.57 c/lb storage and feeding costs in the case study farm which therefore do not appear as excessive as first thought. The importance of the storage costs on the nitrogen farm is not so much that they are high as that they apply by definition to all feed produced, not just as in the case of hay or vacuum silage to surplus summer growth conserved for winter and early spring.

The following table gives in fuller detail the costs of feed production and storage for lucerne hay, barley and lucerne meal for comparison with dairy grazing costs and with the costs on the case

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[7] From Minson [28], Monteath [29], Farm Management Department, Lincoln College [13].

study beef farm. Again, it should be noted that all costs include a full allowance for labour and management reward, interest and depreciation on land and equipment etc.

TABLE XII

Costs of Providing Some Alternative Feeds

	Production Cost	Harvest, Storage & Feeding Out Cost	Total Cost
		c/lb Dry Matter	
Dairy Farm Grazing	0.77	-	0.77
Maize silage/Winter Spring ryegr. (110 acre farm)	0.60	0.57	1.17
Lucerne Hay	0.32	0.48	0.80
Barley	-	-	1.74
Lucerne Meal	0.42[1]	0.72	1.14

[1] Price to farmer paid by Canterbury lucerne processing factory.

On this basis lucerne hay and meat appear very competitive with the maize/grass feed while barley appears excessively high.

However, when we start making comparisons between lucerne grass and barley, a more realistic comparison is effected if we measure the costs per lb of <u>starch equivalent</u> rather than per lb of dry matter, since barley on a starch equivalent basis is a much more nutritive feed than grass.

The following table gives the above costs but expressed per lb of starch equivalent.

TABLE XIII

Costs per lb of Starch Equivalent

of Some Alternative Feeds

	Total Cost per lb of Dry Matter c/lb	Starch Equivalent Percentage on a Dry Matter Basis	Cost per lb of Starch Equivalent c/lb
Dairy Farm Grazing	0.77	70%	1.10
Maize silage/winter grass (110 acre farm)	1.17	64%	1.83
Lucerne Hay	0.80	42%	1.90
Barley	1.74	82%	2.12
Lucerne Meal	1.14	50%	2.28

The result of this calculation is to bring the costs of all feeds other than grazing much more into line with each other - especially the relative price of barley compared with maize silage. This is further reinforced if we consider the relative feed costs per lb of meat for maize silage compared with barley.

	lbs of feed required per lb of meat	Price of Feed c/lb	Feed Cost of lb of Meat c/lb
Corn Silage/grass (110 acre farm)	13.55	1.17	15.8
Barley	8.00	1.74	13.9

Barley at these feed conversion rates is clearly a cheaper food. Since its production is, unlike maize, not so restricted in terms of soil type, climate, topography etc., and since the technology of producing it, storing it, and feeding it, are well understood, it, along with other grains, should be considered for large parts of New Zealand as a preferable method of raising dry matter yields.

This point is taken up further in the next section where we deal with nitrogen using some alternatives to the maize operation.

For the present, the conclusion of this and the preceding sections, is as follows. The maize/grass with nitrogen operation is an economic way of producing much larger quantities of dry matter than are secured from grazing pastures, but it is at present rendered uneconomic by the high cost of harvesting, storing and delivering the feed to the animal's mouth by comparison with grazing methods. Given present technology, it does not seem possible to find cheaper alternative ways of storage which could offset this disadvantage.

A rough measure of the reduction in capital costs required to secure an improved rate of return on capital is provided by the following table. This gives the results from calculations in which we set a target rate of return of 5% and 10% for the 110 acre farm and 10% for the 510 acre farm and calculated the level of capital required to secure this return after allowing for the improved profits resulting from lower depreciation and maintenance on the reduced capital.

	110 acre Present Rate of Return 2.5%	510 acre Present rate of Return 6.1%
Present Level of Capital	226,515	1,011,630
Capital required to secure Target Rate of Return of		
5%	178,649	-
10%	125,800	760,721

On the 110 acre farm the reduction in capital required to lift the return to 5% would be about \$48,000, and for 10% about \$100,000 or nearly a 50% reduction - even more if we take only buildings and equipment and ignore land and livestock capital.

In Greig's study [34] a 50% reduction in capital in new buildings and structures only increased return on capital from 3.2% to 7.7%.

To secure a reduction of over 50% in capital cost by new harvesting and storage methods, and new and cheaper methods of housing cattle, will be difficult but the possibilities are worth researching. Current technology suggests it may well be possible to reduce fodder storage and conservation costs through, for example, the use of less expensive types of silos and the adoption of pit-type silage storage for large operations. The resultant economies are likely to be small in the immediate future, but at least they are movements in the right direction.

A further development worthy of investigation is the use of mobile farm driers which give a feed of substantially lower moisture content than silage. The use of driers is unlikely to result in any reduction in farm capital and may well increase total operating costs. Their appeal lies in the fact that Americans are finding that total D.M. intake per animal per day is increased as the moisture content of the feed is reduced. They have obtained intake increases from $1\frac{1}{2}$% of bodyweight to 4% of bodyweight by reducing moisture content of the feed. This aspect should be studied in New Zealand - doubling the daily weight gains would make the whole system a much more exciting economic prospect.

Intensive research into means of reducing capital costs could conceivably produce reductions of the necessary order after 10 years or so. But until this does happen it is difficult to envisage any rapid or large scale adoption of this type of farming as compared with some of the alternatives to which we now turn.

VIII. SOME ALTERNATIVE SUGGESTIONS FOR RAISING DRY MATTER YIELDS

The results of this investigation so far indicate that because of its very high cost and uneconomic operation there is unlikely to be immediately a rapid introduction of maize/grass type farm. Thus it is unlikely that there will be a rapid growth in the demand for nitrogen in New Zealand.

But there are, in our view, a number of other technologies and crop approaches which could be adopted, many of which would require large injections of fertiliser nitrogen over the next decade or so.

The first of these, as it happens, is not nitrogen using. It is mentioned here because it is so important as a cheap method of raising dry matter yields and is therefore bound to be preferred to the more costly maize/grass operation. This is the growing of greater quantities of lucerne.

8.1 Lucerne for grazing, hay, meal or direct protein extraction

Lucerne has already been mentioned above as a very low cost dry matter producer. Its potential per acre is prodigious. Yields of up to 20,000 lb of dry matter have been achieved in the South Island and its potential in the wetter North Island (once the management skills relating to this plant are acquired) are bound to be even greater. The ease with which it is stored and the low cost of this operation have already been mentioned, but in addition it should be noted that the plant is very high in protein and recent investigations of O'Connor [30] have shown that direct extraction of protein from the plant is most efficient. In this way 40% of the protein in lucerne can be converted to edible protein for eventual export compared with a 4% efficiency rate for animals converting it into meat protein.

Being leguminous, lucerne does not require nitrogen but the drilling of winter grass in lucerne stands, to make up for winter dormancy of the plant, could involve the use of small quantities of nitrogen. The two together could easily outyield the maize/grass combination which we have considered so carefully.

8.2 Feed Grain Cropping

We have already mentioned in connection with barley the relative cheapness of crops as a method of producing high quality animal feed which, above all, is easily storable, transportable, and for which all the necessary technological and managerial skills are known and possessed by most South Island farmers. The advantages of the cropping approach are that:

(i) If desired it can be used to cash in on accumulated fertility build-up from clover based grazed pastures.

(ii) Grains are easily stored and transported so that, unlike silage which cannot be transported, there is no need for the whole farm to be turned over to the silo type operation. The demands on topography, climate, special skills etc., are therefore minimised.

(iii) Indeed, the range of feed grains makes it possible for the development (as has already happened) of area and farmer specialisation.

(iv) The earlier harvest of feed grains makes it easier to fit in the Tama ryegrass rotation which is difficult with maize.

(iv) It fits in with the trend in dairy farming and beef fattening towards the supplementing of grazing by small amounts of concentrates.

The relative decline in wool prices has already led to a rapid development of cash cropping in Canterbury and in some cases whole farms are now operating on a continuous cash cropping basis. Clearly this will, if it continues, lead to greater demand for nitrogen.

8.3 Barley

This is mentioned specifically since it has already been shown to be a reasonably low cost stock food and because, as it happens, we do have some experimental data on yield responses to nitrogen which are amenable to economic analysis. We refer to work by McCarthy [31] in which a production function was fitted to a wide range of data on yields from many different combinations of phosphate and nitrogen.

This function indicates that, at present prices for barley and for N & P, the optimum economic application would be 30 lb of N and 21 lbs of P, giving a yield about 13 bushels higher than that secured with no fertiliser.

Nitrogen is not usually used with malting barley because of the required lower protein content, but for feed barley, provided there is not too great a growth and weakness in the straw, much greater production would follow from cheaper nitrogen. In fact from the McCarthy production function we can estimate that with phosphate applications around 2 cwt per acre, the response in barley yields amounts to about 5 lb of grain for the addition of 1 lb of N. With grain at about 2 c/lb and N at 10c/lb, the application of nitrogen is uneconomic. With N at 5c/lb it would be distinctly profitable.

Higher production of barley and a consequent lower price would lead to a rapid increase in its use for cattle fattening since it is already at present prices so close (as indicated before) to the margin of profitability.

8.4 Nitrogen for Autumn and Spring Boost on Permanent Pasture

Lastly we turn to a brief consideration of the use of fertiliser nitrogen as a supplement to clover in autumn and spring.

There is a vast literature[8] on this question and from these references and conversations with agricultural scientists we reach the conclusion that there is likely to be a very rapid increase in the use of nitrogen for this purpose. This will occur on farms producing high valued products, and especially if the price of nitrogen falls. In fact this usage of nitrogen is likely to dominate the scene entirely compared with the other aspects so far discussed.

All the evidence points to a response rate of about 10 lb of dry matter per lb of nitrogen up to an application rate of 40 lb of N per acre. With nitrogen at 10 c/lb it is necessary to convert 10 lbs dry matter into products worth at least 10 c/lb (or more if costs of application are considered), if the application is to be worthwhile. To date this has only been worthwhile with very high valued products like winter milk on quota, or in areas like Southland with long cold winters and clover dormancy.

With higher stocking rates, with the present higher prices for beef and lamb, and certainly with a possible cheapening of fertiliser nitrogen, the use of N in this way becomes much more profitable and is likely to grow dramatically.

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[8] Specifically we refer to: Walker [19], During [17], Williams [20], Clark & Bessell [32], Scott [27], McFarlane and Davies [33], Ball [21]; and personal communications from numerous members of Lincoln College staff.

Already in Southland some leading farmers are applying 2 cwt of Sulphate of Ammonia per acre and securing grass dry matter yields in the spring growing season of up to 160 lb per day. Such pastures could, in the ideal summer climate of Southland, yield up to 20,000 lb dry matter or more and with very intensive summer stocking (up to 14 ewes to the acre) the whole operation is likely to be very profitable.

IX. CONCLUSION

In this discussion paper we have ranged widely over a number of issues related to the use of fertiliser nitrogen, but our main concern has been with a preliminary economic evaluation of the system of farming suggested by Dr K. Mitchell, involving the use of nitrogen fertiliser and producing and storing high yielding fodder crops such as maize and winter ryegrass.

From an evaluation it is clear that this system certainly has much to commend it from the point of view of raising dry matter yields at low cost, and it could certainly lead to a very marked increase in animal production per acre. However, these advantages are secured at a very high economic cost in terms of harvesting and storage of fodder, compared with further continued improvement in conventional grazing systems towards their full potential.

These high harvesting and storage costs find their expression in the very high capital requirements of the system and the relatively low returns carried on this capital. For this reason, it is unlikely that the new system would be adopted quickly since the rate of adoption of new technologies is very much influenced by their profitability.

There is no doubt that a concentrated programme of research could succeed in reducing the high capital and costs of harvesting and storage. Such a programme of research should be put in train now with the hope of rendering the proposition viable by the end of the decade.

These comments must not be taken to imply criticism of Mitchell's suggestions. On the contrary, Dr Mitchell has rendered agriculture a great service by pointing out the areas in which pioneering effort is required. By casting his ideas in an economic mould, we hope that some of the problems are highlighted. Above all, bearing in mind how tentative are our data and assumptions, we hope that our analysis will be criticised and will lead to further discussion.

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APPENDIX I

THE DETAIL OF THE BEEF CASE STUDY FARM 110 ACRES

(1) LAND

110 acres of arable land in the North/South Auckland area, capable of 15,000 lbs D.M. production from improved pasture, and purchased for $500 per acre. This figure includes land, plus normal levels of buildings and improvements, including one house. A second house is built for $12,000 for the owner-manager, but only $2,000 worth of this is regarded as farm capital (office facilities).

(2) UTILISATION

10 ac. House, buildings, shelter
100 ac. Summer hybrid corn (22,000 lbs. D.M./ac.)
Winter S.R. ryegrass (Tama)(14,000 lbs. D.M./ac.).

Corn crop ensiled in silos.

Winter production of Tama ensiled or fed to housed animals as greenchop material.

(3) STORAGE REQUIREMENTS FOR SILAGE

Mid April - assume all corn harvested.

100 acres at 11 s. tons/acre = 1100 s. tons

Now assume begin foraging grass for animals as greenchop at approximately 6 wks (or mid-June). Hence in mid April, are required to have 2 months haylage still ensiled.

14,000 lbs DM x 100 ac. =
1,400,000 lbs haylage total ensiled ÷
12 for monthly requirement = 116,667 lbs
or for two months = 233,330 = 116 s. tons
Storage required for 1216 s. tons

5 x 250 s. ton silos = 1250 s. ton capacity

250 ton silo at $50/s. ton = $12,500

Add $250 transport less $800 farm labour = $11,950 each.

(4) FODDER AVAILABLE FOR FEEDING (D.M. Basis)

Corn silage 11 s. tons/ac. 100 acres	= 1100 s. tons,	
less 13% wastage		957 s. tons
Tama 7 s. tons/ac. 100 acres	= 700 s. tons,	
less 21% wastage		553 s. tons
Total	1800	1510

1510 s. tons fodder available = 3,020,000 lbs D.M.

(5) LIVESTOCK PROGRAMME

Buy 900 lb L.W. store steers (c/cs wt. 470 lb)
At $17 per 100 lbs, average price $80.

Diet

3:2 silage/haylage mixture
Average intake 21 lb D.M./day
Growth rate 2.5 lb/day

Sell

After 4 months, prime. Average time on hand = 120 days
Selling at 1200 lbs c/cs wt. 660 lb)
At $18 per 100 lbs, average price = $120
Margin per head $40 (no premium allowed).

Deaths

1 per cent.

Carrying Capacity

Requirement per head = 120 x 21 lbs = 2520 lbs D.M.
Hence c.c. = 3,020,000/2520 = 1198 animals
or three intakes of 399 animals - say (395)

	Bought	less	Deaths		Sold
Total	1185	-	12	=	1173
or each Intake	395	-	4	=	391

(6) HOUSING REQUIREMENTS (p. 50 AERU 58)

Bunk Feeding Space: $\frac{1}{2}$ x 395 x $\frac{3}{4}$ = 148,' say(150')

Sq. footage standing: 30 sq.ft. x 395 = 11,850 sq.ft.

Barn standing area 80' x 150' = 12,000 sq.ft.
Width of feed bunk & feeding space = 20'
Total width = 100'
One 150' x 100' cattle barn at $1.5/sq.ft. = $22,500.

CAPITAL	$	Annual Dep'n & Rep. & Maint. %	$
Original L & B (Buildings $20,000)	55,000	5	1000
New Buildings			
New house	2,000	5	100
Silos, 5 @ $11,950	59,750	6.5	3884
One 150' x 100' cattle barn @ $1.5/sq.ft.	22,500	5	1125
Auger 125' @ $10/ft.	1,250	15	190
Electricity supply and wiring	1,000	5	50
One 150' feed bunk, conveyor, @ $15/ft.	2,250	10	225
	88,750		
Machinery			
Elecrric motors, 4	365	15	55
Tractors, 4	10,000	20	2000
Self-unloading forage wagons, 3	6,000	15	900
5' forager + extras	4,600	20	920
Silo unloaders @ $1,500, 2	3,000	20	600
Silo loading blower & distributor, 2	2,200	20	440
1 mower and hay conditioner	1,000	15	150
Vacuum slurry wagon	1,000	15	150
Other machinery	3,000	10	300
	31,165		
Livestock			
1185 x 1/3 (395) at any time @ $80/hd	31,600		
Working Capital average required for interest purposes	20,000		
TOTAL FARM CAPITAL (for interest purposes)	226,515		
TOTAL DEPRECIATION, R. & M.			12,089

Annual Budget

Expenditure

		$	
Depreciation, R. & M. (as before)			12,089
Overheads	Admin. Phone, Accountancy	300	
	Insurances,	450	
	Rates	250	1,000
Electricity			620
Labour:	Management	2,800	
	Married Man	2,000	
	Casual	2,000	6,800
Animal Health:			
	Veterinary	80	
	Spray	60	140
Fertiliser 100 acres			
Maize			
	135 lb N at 10c. = $13.50 per acre		
	25 lb P at 12c. = $ 3.00 per acre		
	150 lb K at 4c. = $ 6.00 per acre		
	$22.50 per acre	2,250	
Ryegrass			
	300 lb N at 10c. = $30.00 per acre		
	30 lb P at 12c. = $ 3.60 per acre		
	270 lb K at 4c. = $10.80 per acre		
	$44.40 per acre	4,440	6,690
Lime - 33 ac. at 1 ton($3 per ton)		100	
Spreading - fert. and lime		200	
- nitrogen		300	600
Freight: 92 tons at $3 - fert. & lime		276	
	Livestock In 1185 at $4	4,740	
	Out 1173 at $3	3,519	8,535
Weeds & Pests:			
	Weeds 100 ac. at $4	400	
	Wireworm " " $5	500	
	Armyworm " " $6	600	1,500
Seed:			
	Corn $\frac{1}{4}$ bus/ac. 100 ac. at $14/bus.	350	
	Grass 2/3 " 100 ac. at $ 2/bus.	130	480
Vehicle Expenses:			
	Tractors 3930 hrs at 35 c.	1,376	
	Car	500	1,876
	TOTAL EXPENDITURE		40,330

Profits & Returns on Capital

Income

Cattle A/C. Sales 1173 at $120	140,760	
Less Purchases 1185 " $ 80	94,800	45,960
Less EXPENSES (as before)		40,330
Net pre-tax profit		5,630

$$\text{Return on Capital} = \frac{5,630}{226,515}$$

$$= 2.5\%$$

ALLOCATION OF CAPITAL EQUIPMENT
To Growing, Harvesting Feed, and Producing Beef

	Grow Feed	Harvest & Store Feed	Prod'n Beef	Total
1. Original Buildings	7,000	-	13,000	20,000
2. New Buildings -				
House	-	2,000	-	2,000
Silos	-	59,750	-	59,750
Cattle Barns	-	-	22,500	22,500
Auger, Elect. Feed Bunks	-	4,500	-	4,500
3. Machinery - Motors	-	365	-	365
4. Tractors	5,000	5,000	-	10,000
5. Forage Wagons	-	6,000	-	6,000
6. Forage Harvester	-	4,600	-	4,600
7. Silo Unloader	-	3,000	-	3,000
8. Silo loading blower	-	2,200	-	2,200
9. Mower	-	1,000	-	1,000
10. Vacuum Slurry Wagon	-	-	1,000	1,000
11. Other Machinery	3,000	-	-	3,000
TOTAL	15,000	88,415	36,500	139,915
12. Livestock	31,600			
13. Working Capital	20,000			
14. Land	35,000			

ALLOCATION OF DEPRECIATION, R. & M. & INTEREST TO GROWING, HARVESTING & PRODUCTION

R. & M. + Dep'n	Grow Feed	Harvest & Store Feed	Prod'n	Total R. & M. Dep'n
1. Original Buildings	350	-	650	1,000
2. New House	-	100	-	100
3. Silos	-	3,884	-	3,884
4. Cattle Barns	-	-	1,125	1,125
5. Auger, Elect. & Feed Bunks	-	465	-	465
6. Machinery & Motors	-	55	-	55
7. Tractors	1,000	1,000	-	2,000
8. Forage Harv. wagons & General	-	3,160	-	3,160
9. Cultivation Machinery	300	-	-	300
TOTAL	1,650	8,664	1,775	12,089
Interest				
Total Equipment Capital	15,000	88,415	36,500	139,915
Interest 5%	750	4,421	1,825	6,996
Value Livestock			31,600	31,600
Interest 5%			1,580	1,580
Working Capital Average	6,000	8,000	6,000	20,000
Interest 5%	300	400	300	1,000
Interest on Land	1,750			1,750
TOTAL INTEREST	2,800	4,821	3,705	11,326

Labour Allocation

		Growing	Harvesting	Production
Wages of Management ($^1/_3$ feed. $^2/_3$ prodn.)	2800	930	-	1,870
Hired Labour (½ feed, ½ harvest)	4,000	2,000	2,000	-
	6,800 =	2,930	2,000	1,870

ALLOCATION OF COSTS TO GROWING & HARVESTING OF FEED & PRODUCTION OF BEEF

	Grow Feed	Harvest & Store Feed	Production	Total
1. Fertiliser	7,290	-	-	7,290
2. Freight & Fertiliser	276	-	-	276
3. Weeds & Pests	1,500	-	-	1,500
4. Seed	480	-	-	480
5. Electricity	-	620	-	620
6. Animal Health	-	-	140	140
7. Freight L/Stock	-	-	8,259	8,259
8. Vehicles	750	750	376	1,876
9. A/c. Admin. Phone,	100	100	100	300
10. Rates, Insurance	420	140	140	700
11. Depreciation + R. & M. (as attached)	1,650	8,664	1,775	12,089
12. TOTAL	12,466	10,274	10,790	33,530
13. Labour	2,930	2,000	1,870	6,800
14. TOTAL	15,396	12,274	12,660	40,330
15. Interest	2,800	4,821	3,705	11,326
16. TOTAL	18,196	17,095	16,365	51,656

COSTS OF D.M. PRODUCTION & ANIMAL PRODUCTION

1. COSTS OF PRODUCING FEED PER LB D.M.
(3,020,000 lb to animals' mouth)

Growing	cash + labour	0.510
	Interest	0.093
Total	growing	0.603 c.lb
Harvesting + Storage		
	Cash + labour	0.406
	Interest	0.160
		0.566
TOTAL	Growing + Harvesting & Storage	
	Cash + labour	0.914
	Interest	0.253
		1.167

2. CONVERSION RATIO

lbs D.M. per lb Product $\frac{3,020,000}{222,870}$ = 13.5505 lbs

3. COSTS OF PRODUCTION PER LB MEAT

			c. per lb Meat
Feed Production			
	Cash + labour	(0.510 x 13.5505)	6.91
	Interest	(0.093 x 13.5505)	1.26
	TOTAL		8.17
Harvesting & Storage			
	Cash + labour	(0.406 x 13.5505)	5.50
	Interest	(0.160 x 13.5505)	2.17
	TOTAL		7.67
Animal Production			
	Cash & labour costs		5.68
	Interest		1.66
	TOTAL		7.34
TOTAL COSTS			
	Cash + labour		18.09
	Interest		5.09
	TOTAL		23.18
Price received per lb		45,960/222,870	20.62 c.

APPENDIX II

DETAIL OF THE 510 ACRE BEEF CASE STUDY FARM

1. Land & Utilisation 510 acres.

10 acres - buildings, shelter

500 acres - summer, hybrid corn (22,000 lbs DM/ac)
- winter, Tama (14,000 lbs DM/ac)

2. Storage Requirements

500 acres at 11 tons/acre	=	5,500 tons
14,000 lb DM = 7 s.tons x 500 acres = 3500 tons total ensiled. Two months ÷ 6	=	585 tons
Storage requirements		6,085 tons

25 x 250 ton silos = capacity 6,250 tons.

250 ton silo at \$45/s.ton = \$11,250
+ 250 transport = \$11,500 each.

3. Fodder Available for Feeding

Corn silage 11 tons, 500 acres =	5,500 tons		
13% wastage		=	4,785
Tama silage 7 tons 500 acres =	3,500 tons		
21% wastage		=	2,765
	9,000		7,550 tons

7,550 tons = 15,100,000 lbs DM.

4. Livestock Programme

Carrying Capacity, 15,100,000/2,520 = 5,992 animals or three intakes of 1,997, say 1950 animals.

	Bought	less	Deaths		Sold
Total	5,850	-	60	=	5,790
per intake (3)	1,950	-	20	=	1,930

5. <u>Housing Requirements</u>

<u>Bunk feeding space:</u>

$\frac{1}{2}$ x 1950 x $\frac{3}{4}$ = 731 say750

5 barns (80' x 150' = 12,000) = 60,000 sq.ft.

Standing Area

30 sq.ft. x 1950 = 58,500

1 barn 100' x 150' = 15,000 sq.ft. at $1.5 per sq.ft.

= $22,500

5 barns = $112,500

6. <u>Meat Produced</u>

5,790 sold at 660 c/s. wt.	= 3,821,400
5,850 bought at 470 c/s. wt.	= 2,749,500
net lbs produced	1,071,900

CAPITAL	$	Annual Dep'n Repairs & Maintenance
Original L & B (Buildings $100,000)	275,000	5,000
New Buildings		
House (new)	8,000	400
25 silos at $11,500 each	287,500	18,688
5 cattle barns	112,500	5,625
1 auger 400'	5,000	750
Electricity supply	4,000	200
5 x 150' feed bunk at $15/ft.	11,250	1,125
	428,250	
Machinery		
Electric motors 13	1,080	162
Tractors 9	25,200	5,040
6 forage wagons s.u.	12,000	1,800
3 foragers + extras	13,800	2,760
6 silo unloaders	9,000	1,800
3 silo loading blowers	3,300	660
3 mower & hay conditioners	3,000	450
Vacuum slurry wagon	1,000	150
Other machinery	4,000	400
TOTAL DEPRECIATION	72,380	45,010
Livestock		
1950 at $80/hd.	156,000	
Working Capital		
Interest purposes	80,000	
TOTAL FARM CAPITAL	$1,011,630	

EXPENDITURE	$	$
Depreciation R & M		45,010
Overheads		
A/c. Admin., Phone	500	
Insurances	1,000	
Rates	1,000	2,500
Electricity		2,200
Labour		
Management	3,800	
Married Men	16,000	
Casual	-	19,800
Animal Health		
Veterinary	400	
Spray	300	700
Fertiliser		
Maize/Tama	33,450	
Lime & Spreading	3,000	36,450
Freight		
Fertiliser	1,350	
Livestock, In 5850 at $4	23,400	
Out 5790 at $3	17,370	42,120
Weeds & Pests		7,500
Seed		2,400
Vehicle Expenses		
Tractors	6,000	
Car	600	6,600
TOTAL ANNUAL EXPENSES	165,280	

Profits & Return on Capital

Income		
Cattle Sales 5790 at $120	694,800	
less Purchases 5850 at $80	468,000	226,800
less Expenses		165,280
Net Pre-tax Profit (loss)		61,520

$$\text{Return on Capital} = \frac{61,520}{1,011,630} = 6.1\%$$

ALLOCATION OF CAPITAL EQUIPMENT

	Grow Feed	Harvest & Store $	Production	Total
1. Original Building	67,000		33,000	100,000
2. New: House		8,000		8,000
Silos		287,500		287,500
Cattle Barns			112,500	112,500
Auger, Elect. Bunks		20,250		20,250
3. Machinery - motors		1,080		1,080
4. Tractors	12,600	12,600		25,200
5. Forage Wagons		12,000		12,000
6. Forager		13,800		13,800
7. Silo unloader		9,000		9,000
8. Silo unloader blower		3,300		3,300
9. Mower		3,000		3,000
10. Vacuum Slurry Wagon			1,000	1,000
11. Other	4,000			4,000
Total	83,600	370,530	146,500	600,630
12. Livestock	156,000			
13. W.C.	80,000			
14. Land	175,000			
Total Capital		1,011,630		
Less Land		175,000		
		836,630		

ALLOCATION OF DEPRECIATION - R & M AND INTEREST

R & M Dep'n	Grow Feed	Harvest & Store	Production	Total
1. Original Buildings	1,750		3,250	5,000
2. New House		400		400
3. Silos		18,688		18,688
4. Cattle Barns			5,625	5,625
5. Auger, Elect. Bunks		2,075		2,075
6. Machinery, Motors		162		162
7. Tractors	2,520	2,520		5,040
8. Forage Wagon & Gen.		7,620		7,620
9. Cultivating Machinery	400			400
	4,670	31,465	8,875	45,010

Interest				
Total Equipment Capital	83,600	370,530	146,500	600,630
Interest 5%	4,180	18,527	7,325	30,032
Value Livestock			156,000	156,000
Interest 5%			7,800	7,800
Working Capital Average	25,000	30,000	25,000	80,000
Interest 5%	1,250	1,500	1,250	4,000
Interest on Land	8,750			8,750
TOTAL INTEREST	14,180	20,027	16,375	50,582

COSTS OF GROWING, HARVESTING & PRODUCTION

	Grow Feed	Harvest & Store	Production	Total
1. Fertiliser	36,450			36,450
2. Freight, Fertiliser	1,350			1,350
3. Weeds & Pests	7,500			7,500
4. Seed	2,400			2,400
5. Electricity		2,200		2,200
6. Animal Health			700	700
7. Freight, Livestock			40,770	40,770
8. Vehicles	2,900	2,900	800	6,600
9. A/c. Admin. Phone	160	160	180	500
10. Rates, Insurance	1,400	300	300	2,000
11. Dep'n & R&M	4,670	31,465	8,875	45,010
12. Total	56,830	37,025	51,625	145,480
13. Labour	7,500	5,800	6,500	19,800
14. Total	64,330	42,825	58,125	165,280
15. Interest	14,180	20,027	16,375	50,582
Total	78,510	62,852	74,500	215,862

COSTS OF D.M. PRODUCTION & ANIMAL PRODUCTION

1. Costs of Production Feed (per lb DM)(15,100,000 lbs)

		c/ lb DM.
Growing	cash + labour	.43
	Interest	.09
	Total growing	.52
Harvesting & storage		
	Cash + labour	.29
	Interest	.13
		.42
Total Grow, Harvest, Store		
	Cash + labour	.72
	Interest	.22
		.94

2. Conversion Ratio
   lbs DM per lb Product $\frac{15,100,000}{1,071,900}$ = 14.087

3. Costs of Production per lb meat

		c.per lb meat
Feed Production		
	Cash + labour	6.06
	Interest	1.27
	Total	7.33
Harvesting & Storage		
	Cash + labour	4.09
	Interest	1.83
	Total	5.92
Animal Production		
	Cash + labour	5.42
	Interest	1.53
	Total	6.95
Total Costs		
	Cash + labour	15.42
	Interest	4.72
	Total	20.14

Price received per lb. 226,800/1,071,900 21.16

APPENDIX III

DETAIL OF BUDGET FOR 110 ACRE FACTORY SUPPLY DAIRY FARM

(1) LAND

110 acres of arable land in the North/South Auckland area, capable of 15,000 lbs D.M. production from improved pasture, and purchased for $500 per acre. This figure includes land, plus normal levels of buildings and improvements, including one house.

(2) UTILISATION

10 ac. House, buildings, shelter
100 ac. Summer hybrid corn (22,000 lbs D.M./ac.).
Winter S.R. ryegrass (Tama)(14,000 lbs D.M./ac.).

* Corn crop ensiled in silos.
* Winter production of Tama ensiled or fed to housed animals as greenchop material.

(3) STORAGE REQUIREMENTS FOR SILAGE

Mid April - assume all corn harvested.

100 acres at 11 s.tons/acre = 1100 s.tons

Now assume begin foraging grass for animals as greenchop at approximately 6 weeks (or mid-June). Hence in mid April, are required to have 2 months haylage still ensiled.

14,000 lbs D.M. x 100 ac. =
1,400,000 lbs haylage total ensiled ÷
12 for monthly requirement = 115,667 lbs
or for two months = 233,330 = 116 s.tons

Storage required for 1216 s.tons

5 x 250 s.ton silos =1250 s.ton capacity

250 ton silo at $50/s.ton = $12,500

Add $250 transport less $800 farm labour = $11,950 each

(4) LIVESTOCK PROGRAMME

Replacements are bought in as in-calf heifers. Jerseys are fed silage, consuming 9100 lbs D.M. per year (10 in bibliography). Hence carrying capacity is 3,020,000/9,100, i.e. 332 cows.

(5) Housing Requirements

One cubicle per cow and 12 inches of bunk feeding space per cow has been allowed. For details of layout, see McClatchy (16 in bibliography).

CAPITAL & DEPRECIATION AND REPAIRS AND MAINTENANCE

	$	Rate	Depr'n. & R&M.
Original L&B(buildings $20,000)	55,000	5	1,000
New Buildings			
New Houses (2)(proportion)	4,000	5	200
Silos 5 at $11,950	59,750	6.5	3,884
Cubicles, 332 at $15	4,920	5	246
Concrete Yard area	1,500	2.5	38
Feed Bunks, Auger	3,500	15	525
Effluent Tank	1,300	5	65
Electricity Supply	1,000	5	50
Machinery			
Electric Motors	365	15	55
Tractors (4)	8,000	20	1,600
Self-load, forage wagons (3)	6,000	15	900
Forager + extras	4,600	20	920
Silo unloaders (2)	3,000	20	600
Silo loading blower (2)	2,200	20	440
Mower & hay conditioner	1,000	15	150
Vacuum slurry wagon	1,000	15	150
Other machinery	3,000	10	300
Livestock			
332 Jersey cattle at $80	26,560		
Working Capital (av. for interest purposes)	6,000		
TOTAL FARM CAPITAL (for interest purposes)	192,755		
TOTAL DEPRECIATION, REPAIRS & MAINTENANCE			$11,123

ANNUAL EXPENDITURE

	$	$
Depr'n. R & M		11,123
Overheads		
Accounts, Admin., Phone	300	
Insurance	400	
Rates	250	950
Electricity		600
Shed Expenses ($2.00 per head)		664
Herd Testing		400
A.B.		650
Animal Health		
Veterinary	550	
Spray, drench	100	650
Labour		
Management	2,500	
Married Men (2)	4,000	
Casual	1,000	7,500
Fertiliser plus spreading, 100 acres		7,290
Freight In 60 hfrs. at $3	180	
Out 56 culls at $1.20	65	
Fertiliser	275	520
Weeds & Pests		1,500
Seeds		480
Vehicle Expenses		
Tractors 4000 hrs at 35 c.	1,400	
Car	200	1,600
TOTAL EXPENDITURE		$33,927

INCOME & RETURNS ON CAPITAL

	25c. $	30c. $	35c. $
332 Jerseys at 350 lbs Butterfat per head = 116,200 lbs fat -			
at 25c.	29,050		
at 30c.		34,860	
at 35c.			40,670
56 Culls at $35	3,080	3,080	3,080
320 Bobbies at $6	1,920	1,920	1,920
Less 60 in-calf heifers purchased at $80	4,800	4,800	4,800
GROSS INCOME	29,250	35,060	40,870
LESS EXPENSES	33,927	33,927	33,927
NET INCOME	-4,677	1,133	6,943
RETURN ON CAPITAL ($192,755)	-2.4%	0.6%	3.6%

ALLOCATION OF CAPITAL EQUIPMENT TO GROWING FEED, HARVESTING FEED, & PRODUCING BUTTERFAT

	Grow Feed	Harvest & Store Feed	Production Butterfat	TOTAL
Original Buildings	7,000	-	13,000	20,000
New Houses	-	2,000	2,000	4,000
Silos	-	59,750	-	59,750
Cubicles	-	-	4,980	4,980
Concrete Yard	-	-	1,500	1,500
Feed Bunks, Auger Electricity	-	4,500	-	4,500
Effluent Tank	-	-	1,300	1,300
Electric Motors	-	365	-	365
Tractors	4,000	4,000	-	8,000
Forage Wagons	-	6,000	-	6,000
Forager	-	4,600	-	4,600
Silo unloaders	-	3,000	-	3,000
Loading Blower	-	2,200	-	2,200
Mower & Conditioner	-	1,000	-	1,000
Vacuum Slurry Wagon	-	-	1,000	1,000
Other machinery	3,000	-	-	3,000
	14,000	87,415	23,780	125,195

Live stock	26,560
Working Capital	6,000
Land	35,000

ALLOCATION OF DEPRECIATION, REPAIRS & MAINTENANCE & INTEREST TO GROWING FEED, HARVESTING & STORING FEED & PRODUCTION BUTTERFAT

Repairs & Maintenance & Depreciation	Grow Feed	Harvest & Store Feed	Production Butterfat	TOTAL
Original Buildings	350	-	650	1,000
New House	-	100	100	200
Silos	-	3,884	-	3,884
Cubicles, Yard Area, Effluent Tank	-	-	349	349
Auger Electricity, Feed Bunks	-	575	-	575
Motors	-	55	-	55
Tractors	800	800	-	1,600
Forager & General	-	3,160	-	3,160
Other	300	-	-	300
TOTAL	1,450	8,574	1,099	11,123
Interest				
Total Equipment Capital	14,000	87,415	23,780	125,195
Interest 5%	700	4,371	1,189	6,260
Value Livestock			26,560	26,560
Interest 5%			1,328	1,328
Av. working capital	1,500	3,000	1,500	6,000
Interest 5%	75	150	75	300
Interest on Land	1,750	-	-	1,750
TOTAL INTEREST	2,525	4,521	2,592	9,638

ALLOCATION OF COSTS TO GROWING & HARVESTING FEED & PRODUCTION BUTTERFAT

	Grow Feed	Harvest & Store Feed	Production Butterfat	TOTAL
Fertiliser & Freight	7,565	-	-	7,565
Weeds & Pests	1,500	-	-	1,500
Seed	480	-	-	480
Electricity	-	300	300	600
Animal Health	-	-	650	650
Shed Expenses, Herd Testing & A.B.	-	-	1,714	1,714
Freight, L/Stock	-	-	245	245
Vehicles	700	700	200	1,600
A/c., Admin., Phone	100	100	100	300
Rates, Insurance	350	150	150	650
Depr'n., R & M.	1,450	8,574	1,099	11,123
TOTAL	12,145	9,824	4,458	26,427
Labour	2,000	2,000	3,500	7,500
TOTAL	14,145	11,824	7,958	33,927
Interest	2,525	4,521	2,592	9,638
TOTAL	16,670	16,345	10,550	43,565

COSTS OF DRY MATTER PRODUCTION & BUTTERFAT PRODUCTION

(1) COSTS OF PRODUCTION FEED PER LB DRY MATTER
(3,020,000 lbs to Animals' mouth)

	c/lb D.M.
Growing	
Cash + Labour	0.47
Interest	0.08
Total	0.55
Harvest + Storage	
Cash + Labour	0.39
Interest	0.15
Total	0.54
Total Growing, Harvesting & Storage	
Cash + Labour	0.86
Interest	0.23
	1.09

(2) CONVERSION RATIO
lbs DM/lb Butterfat $\frac{3,020,000}{116,200}$ = 26.0 lbs DM per lb Fat

(3) COSTS OF PRODUCTION PER LB BUTTERFAT

	c/lb Fat
Feed Production	
Cash + Labour	12.17
Interest	2.17
Total	14.34
Harvesting + Storage	
Cash + Labour	10.18
Interest	3.89
Total	14.07
Animal Production	
Cash + Labour	6.85
Interest	2.23
Total	9.08

(cont'd)

		c/lb Fat
TOTAL COSTS		
Cash + Labour		29.20
Interest		8.29
		37.49
Price received per lb Bf.	at 25c.	25.17
(incl. other income)	at 30c.	30.17
	at 35c.	35.17

APPENDIX IV

DETAIL OF BUDGET FOR 510 ACRE FACTORY SUPPLY DAIRY FARM

(1) Land & Utilisation 510 acres.

10 acres - building, shelter

500 acres - summer, hybrid corn (22,000 lbs DM/ac)

- winter, Tama ryegrass (14,000 lbs DM/ac)

(2) Storage Requirements

500 acres at 11 tons/acre	=	5,500 tons
14,000 lb DM = 7 s. tons x 500 acres = 3500 tons total ensiled. Two months ÷ 6	=	585 tons
Storage requirements		6,085 tons

25 x 250 ton silos = capacity 6,250 tons

250 ton silo at $45/s. ton = $11,250

+ 250 transport = $11,500 each.

(3) Fodder Available for Feeding

Corn silage 11 tons, 500 acres 13% wastage	= 5,500 tons	=	4,785 tons
Tama silage 7 tons 500 acres 21% wastage	= 3,500 tons	=	2,765 tons
	9,000 tons		7,550 tons

7,550 tons = 15,100,000 lbs DM.

(4) Livestock Programme

Replacements are bought in as in-calf heifers. Jerseys are fed silage only (assuming this is an adequate diet) at the rate of 9100 lbs DM/year (see Coop, reference 6 in bibliography).

Hence carrying capacity	=	15,100,000/9100 lbs
	=	1660 cows
Replacements (18%)	=	300
Deaths (1%)	=	20
Culls	=	280

(5) Housing Requirements

One cubicle per cow and 12 inches of bunk feeding space per cow has been allowed. For details of layour, see McClatchy (16, p.60).

CAPITAL, DEPRECIATION AND REPAIRS & MAINTENANCE

	$	% Rate	Annual Depr/n. and R & M.
Original L & B (Buildings ($100,000))	275,000	5	5,000
New Buildings			
New Houses (proportion)	8,000	5	400
Silos 25 at $11,500	287,500	6.5	18,688
Cubicle 1660 at $12	19,920	5	995
Concrete Yard Area	5,000	2.5	125
Feed Bunks, Auger	16,250	11.5	1,875
Effluent Tank	4,000	5	200
Electricity Supply	4,000	5	200
	344,670		
Machinery			
Electric Motor	1,080	15	162
Tractors (9)	25,200	15	5,040
Self-unload. Forage Wagons (6)	12,000	15	1,800
Forager plus extras (3)	13,800	20	2,760
Silo unloaders (6)	9,000	20	1,800
Silo loading Blowers (3)	3,300	20	660
Mower & hay conditioner (3)	3,000	15	450
Vacuum Slurry Wagon	1,000	15	150
Other Machinery	4,000	10	400
	72,380		
Livestock			
1660 at $80 per head	132,800		
Working Capital (av. for int. purposes)	25,000		
TOTAL FARM CAPITAL (for int. purposes)	849,850		
TOTAL DEPRECIATION, REPAIRS & MAINTENANCE			$40,705

EXPENDITURE

	$	$
Depreciation, Repairs & Maintenance		40,705
Overheads Accounts, Admin., Phone	400	
Insurance	1,000	-
Rates	1,000	2,400
Electricity		2,400
Shed Expenses ($2.00 per hd)		3,320
Herd Testing		2,500
A.B.		4,700
Animal Health		
Veterinary	2,000	
Spray, drench	500	2,500
Labour		
Management	3,500	-
Married Men (12)	24,000	-
Casual	-	27,500
Fertiliser plus spreading, 500 acs.		36,450
Freight		
In 300 hfrs at $3	900	
Out 280 culls at $1.20	336	
Fertiliser	1,350	2,586
Weeds & Pests		7,500
Seed		2,400
Vehicle Expenses		
Tractors	6,000	
Car	600	6,600
TOTAL ANNUAL EXPENSES		$141,561

INCOME & RETURN ON CAPITAL

Income	Price Butterfat		
	25c.	30c.	35c.
1660 Jerseys at 350 lbs b/fat			
per hd = 581,000 lbs fat			
at 25c.	145,250		
at 30c.		174,300	
at 35c.			203,350
280 culls at $55	15,400	15,400	15,400
1600 Bobbys at $6	9,600	9,600	9,600
Less 300 in-calf heifers			
purchases at $80	24,000	24,000	24,000
Gross Income	146,250	175,300	204,350
Less Expenses	141,561	141,561	141,561
Net Income	4,689	33,739	62,789
Return on Capital ($849,850)	0.6%	4.0%	7.4%

ALLOCATION OF CAPITAL EQUIPMENT

	Growing Feed	Harvest & Store Feed	Production Butterfat	TOTAL
Original Buildings	35,000	-	65,000	100,000
New Houses	-	4,000	4,000	8,000
Silos	-	287,500	-	287,500
Cubicles	-	-	19,920	19,920
Concrete Yard	-	-	5,000	5,000
Feed Bunks, Auger & Electricity	-	20,250	-	20,250
Effluent Tank	-	-	4,000	4,000
Electric Motors	-	1,080	-	1,080
Tractors	12,600	12,600	-	25,200
Forage Wagons	-	12,000	-	12,000
Forager	-	13,800	-	13,800
Silo unloaders	-	9,000	-	9,000
Loading Blowers	-	3,300	-	3,300
Mower & Conditioner	-	3,000	-	3,000
Slurry Wagon	-	-	1,000	1,000
Other	4,000	-	-	4,000
	51,600	366,530	98,020	517,050

Livestock	132,800
Working Capital	25,000
Land	175,000

ALLOCATION OF DEPRECIATION, REPAIRS & MAINTENANCE

Repairs & Maintenance & Depreciation	Growing Feed	Harvest & Store Feed	Production Butterfat	TOTAL
Original Buildings	1,750	-	3,250	5,000
New Houses	-	200	200	400
Silos	-	18,688	-	18,688
Cubicles, Yard, Effl. Tank	-	-	1,320	1,320
Auger, Electricity, Bunks	-	2,075	-	2,075
Motors	-	162	-	162
Tractors	2,520	2,520	-	5,040
Forager & General	-	7,620	-	7,620
Other	400	-	-	400
TOTAL	4,670	31,265	4,770	40,705

Interest				
Total Equipment Capital	51,600	366,530	98,920	517,050
Interest at 5%	2,580	18,326	4,946	25,852
Value Livestock	-	-	132,800	132,800
Interest 5%	-	-	6,640	6,640
Av. Working Capital	8,000	9,000	8,000	25,000
Interest 5%	400	450	40 0	1,250
Interest on land	8,750	-	-	8,750
TOTAL INTEREST	11,730	18,776	11,986	42,492

ALLOCATION OF COSTS TO GROWING, HARVESTING & STORING FEED AND PRODUCTION OF BUTTERFAT

	Growing Feed	Harvest & Store Feed	Production Butterfat	TOTAL
Fertiliser & Freight	37,800	-	-	37,800
Weeds & Pests	7,500	-	-	7,500
Seed	2,400	-	-	2,400
Electricity	-	1,200	1,200	2,400
Animal Health	-	-	2,500	2,500
Shed Expenses, Herd Testing, & A.B.	-	-	10,520	10,520
Freight Livestock	-	-	1,236	1,236
Vehicles	3,000	3,000	600	6,600
A/C., Admin., Phone	150	100	150	400
Rates, Insurance	1,000	500	500	2,000
Depr'n. R & M.	4,670	31,265	4,770	40,705
TOTAL	56,520	36,065	21,476	114,061
Labour	8,000	8,000	11,500	27,500
TOTAL	64,520	44,065	32,976	141,561
Interest	11,730	18,776	11,986	42,492
TOTAL	76,250	62,841	44,962	184,053

COSTS OF DRY MATTER PRODUCTION & BUTTERFAT PRODUCTION

(1) COSTS OF PRODUCTION, FEED PER LB DRY MATTER
(15.1 mn lbs to animal's mouth)

	c. per lb D.
Growing	
Cash + labour	0.43
Interest	0.08
Total	0.51
Harvest & Storage	
Cash + labour	0.29
Interest	0.12
Total	0.41
Total Growing, Harvest & Storage	
Cash + labour	0.72
Interest	0.20
Total	0.92

(2) CONVERSION RATIO

lbs DM per lb product = 15.1 mn lb DM/0.581 mn lb Fat

= 26.0 as DM per lb Fat.

(3) COSTS OF PRODUCTION PER LB BUTTERFAT	c. per lb Meat
Feed Production	
Cash + labour	11.10
Interest	2.02
Total	13.12
Harvesting & Storage	
Cash + labour	7.58
Interest	3.23
Total	10.81
Animal Production	
Cash + labour	5.68
Interest	2.06
Total	7.74
TOTAL COSTS	
Cash + labour	24.36
Interest	7.31
Total	31.67
Price Received per lb Butterfat	
(incl. other income)) at 25c.	25.17
) at 30c.	30.17
) at 35c.	35.17