THE UNIVERSITY RESEARCH FARM AT OYSTER RIVER - AN ECONOMIC EVALUATION OF ITS OPERATION AND SOME ALTERNATIVE ENTERPRISE COMBINATIONS

by

THOMAS GEORGE NISBET

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We accept this thesis as conforming to the required standard.

THE UNIVERSITY OF BRITISH COLUMBIA

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Department of Agricultural Economics

The University of British Columbia,
Vancouver 8, Canada

Date May 20, 1965.

ABSTRACT

The objective of this study was to examine the farm organization and management of the University Research Farm at Oyster River. Its present resource use and a normative analysis postulating a more desirable organization of enterprises is presented.

The method for the positive analysis was to prepare inventories, net worth statements and operating statements for the fiscal years 1962-63, 1963-64, and for the calendar year 1964. From this data, measures of performance were calculated and compared with similar data from regional studies of dairy farming on Vancouver Island and in the Fraser Valley. In addition, comparisons were made with budget studies in Washington State.

The University Farm operated at a loss in each of the three periods, although the results for the 1964 calendar year showed considerable improvement. Costs at Oyster River farm were higher than in the studies used for comparison, due to higher overhead costs and higher wage rates. However, measures of physical performance were generally equal to regional averages. In making this evaluation, consideration was given to the development and expansion programs undertaken in recent years. The record keeping system was reviewed, and an alternative method proposed which will facilitate the evaluation of factor use.

Linear programming was chosen for the normative analysis, because it had the advantage of being able to recommend optimal enterprise combinations after considering a relatively large number of alternative activities and resource constraints. Although more activities could have been considered in the programmes, it was decided a priori to limit the number to those which could reasonably be established immediately, or in a period of a few years. Included in this study were 15 dairy activities, two for beef, one for sheep, and one for potatoes. It was necessary to consider the purchase of hay and the employment of additional labour. Resource constraints were included for land, nine labour periods, operating capital and building space.

Of the five analyses undertaken, one included as a prerequisite 30 Ayrshire cows and permitted labour purchases for all periods. This particular analysis is of interest in view of the necessity for maintaining the Ayrshire herd for experimental purposes. With this initial herd requirement the optimum plan also introduced 56 Holstein cattle and 40 acres of potatoes. The return to fixed factors of production was maximized at $29,324.51, representing a rate of return on investment of 5.8%. The stability of the optimum plans with respect to price changes was determined.

The normative analysis specifies a higher level of production per cow than is presently being achieved, but the level is within the reach of a commercial operation. A more serious limitation lies in the establishment of a shipping quota for

potatoes. It would take a number of years to establish an adequate quota and the initial acreage would have to be on a smaller scale. However, in principle the situation is no different from that encountered in building up a milk quota, and therefore the establishment of a potato enterprise may be regarded as a desirable long-run objective.

The remaining four analyses define optimal programmes for recommended activities under varying conditions of enterprise combination and resource availability.

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CHAPTER 1

INTRODUCTION

Objectives and Methodology

The objectives for this assignment were: (1) to consider the University Research Farm at Oyster River as a commercial operation and evaluate the pattern of resource use under present operating conditions and (2) to consider alternative enterprise combinations that show promise of improving resource utilization.

Method

The thesis has been prepared in two main parts, the first containing the positive analysis and the second containing the normative analysis. The term "positive" is used in the sense of positive economics or the explanation of matters as they presently exist. The normative analysis is prescriptive in nature, postulating conditionally, a more desirable state of affairs.

In Chapter II an account is presented of the farm operation and of the development of the farm to the present state. This is followed by a summary of the financial accounts for the calendar year 1964 and for the fiscal years 1962-63 and 1963-64. A comparison is made of measures of financial and physical performance at Oyster River and compared with similar farms in the Fraser Valley, in Washington State and on Vancouver Island. Finally, the farm record keeping system is evaluated.

In Chapter III details of the normative solutions are

presented. A normative solution prescribes the action that should be taken to attain a predetermined objective subject to alternative activities and resource restrictions. Having correctly defined the problem, the objective will be achieved in a manner that most efficiently utilizes the limiting resources. Two methods are common in a problem of this kind. The first is budgeting where the size of the problem is not large, the second is linear programming which can handle more involved problems. The information required for both approaches is essentially the same but linear programming provides a more systematic way of determining an optimum solution when the problem involves more activities. Linear Programming was the method chosen for this study. In addition to its advantage in handling complex problems the availability of an I.B.M. 7040 electronic computer greatly facilitated the task of determining the effect on optimum solutions for different problem formulations. Having decided that linear programming was an appropriate tool the next step was to determine and define the relevant number of activities and resource restrictions. Consequently, the problem of defining technical coefficients and resource restrictions is discussed in some detail because of its importance in obtaining meaningful results.

Although a large number of activities could have been handled representing many different and new enterprises it was decided to limit the choice of activities, a priori, to those activities that could reasonably be expected to be implemented in the short run (2-3 years).[1]

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1 An activity is defined here as an enterprise or a production process.

Most of the alternative activities in the linear programming problem centered around the dairy enterprise although beef, sheep, and potatoes were also taken into account. The reason for this is that (1) dairying is the predominant agricultural activity in the area and would thus appear better suited and more profitable than other activities and (2) the farm is already committed to a predominantly dairy operation and is not likely to change in the next several years. The choice of other activities was conditioned by their potential profitability compared to dairying, their demand for resources, the market for the product and the activities other than dairying that are part of the present operation. As a result consideration was given to 15 dairy activities, two beef activities and one each for sheep and potatoes. The remaining activities were for hay purchase (having the effect of adding to the land supply) and labour purchase for the months of May, June, July, August, and September. A second analysis included labour purchasing activities for 9 periods of the year. Preliminary consideration was given to several other enterprises namely; hogs, poultry, strawberry production and tree fruits. These activities were excluded because they failed to satisfy one or more of the above criteria.

ANALYSIS OF THE PRESENT FARMING OPERATION

The University Farm at Oyster River

The University Farm at Oyster River is located 85 miles north of Nanaimo on Vancouver Island, in an area dominated by a relatively large number of small agricultural holdings. These holdings produce a variety of small fruit and tree fruit crops which are sold on the local market. Livestock production is varied and the number of head per farm is small. The predominant type of commercial farming in the Courtenay-Comox area is dairying although several farmers in the Comox Valley have done well by producing small fruits and vegetables on a commercial scale. The market for small fruits and vegetables is however largely a local one.

The climate in the Oyster River area is characterized by relatively heavy precipitation in the winter months followed by a relatively dry summer period. The effect of the heavy winter precipitation has been that sufficient buildings have had to be provided for the entire dairy herd. The low summer precipitation has the effect of limiting forage production, particularly in the late summer months.[2] Supplemental irrigation is used on several farms in the area and could be considered on the University farm. Early and late frosts do not

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2 Precipitation at Courtenay averaged 9.75 inches and 8.53 inches for the months of December and January respectively. The averages for July and August were 1.45 inches and 1.66 inches respectively.
British Columbia Department of Agriculture. Climate of British Columbia . Victoria, Queens printer, 1962. page 13

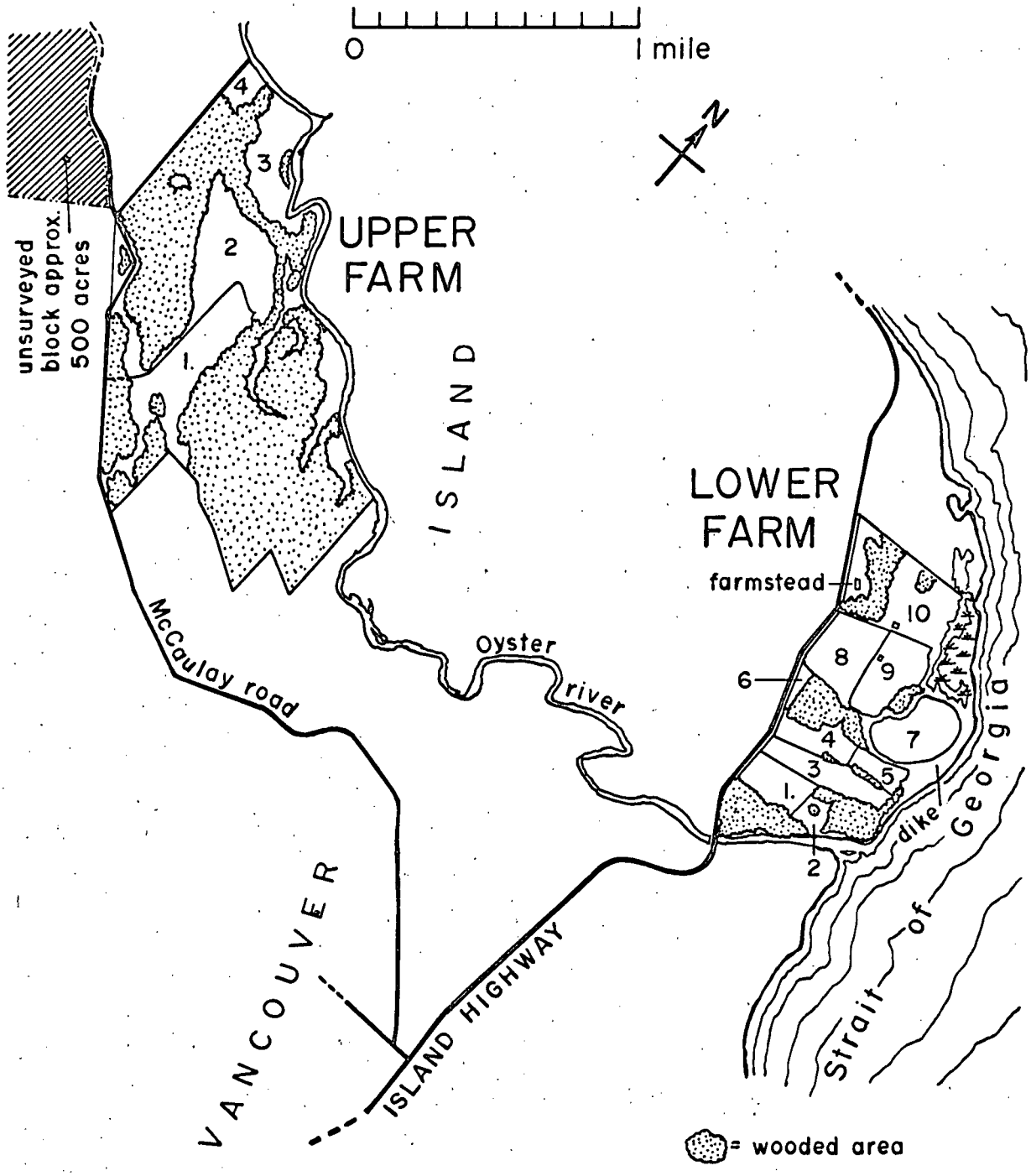

Figure 1. University of British Columbia Research Farm Oyster River B.C.

present any important management problems under the present cropping system. The introduction of crops such as corn for silage or potatoes would require consideration of the possibility of frost damage in late April and early May.

The area of the Oyster River farm has been calculated at 1363.5 acres of which 332 acres are cleared. The farm is geographically separated into the upper and lower farm areas by a distance of 6 miles. (see figure 1) The lower farm has an area of 354 acres (195.6 cleared) and is the more productive while much of the upper farm is of doubtful agricultural value. The cleared area on the upper farm amounts to 136.4 acres and is situated on a series of benches located between MacCaulay road and the Oyster River. An additional 500 acres lies adjacent to but south of MacCaulay road. This area ia uncleared and unfenced. The farm has two geographical disadvantages; (1) its location increases the cost of transporting produce and supplies and makes Faculty administration more difficult and (2) the separation of the farm increases farm operating costs and places a greater burden on management. As recently as 1949 most of the arable land was heavily wooded so that land clearing and development were the predominant activities. As a result, it is only in recent years that more attention has been focussed on the economics of its operation. In 1961 part of the campus dairy herd and milk quota was transferred to Oyster River and this marked the start of the dairy operation. Building construction had started prior to the transfer and continued at intervals to the present date. The most recent construction, in 1964, was a 100 cow dairy barn.

The management policy has been one of increasing the herd size from the original 40 cows to a herd size of about 100 milking cows. Considerable quantities of surplus milk have been shipped in an effort to increase the daily quota. Since shipping quotas are based on demand in the area and production in the preceeding year it was necessary to ship considerable quantities of non-quota milk. The farm has in fact succeeded in increasing its quota from 1300 lbs. daily in 1962 to 2050 lbs. in 1964.

Expanding milk production has led to increased demands for resources with labour and feed being affected most. The cost of hired labour increased from $26,885.00 in 1961 to an estimated $30,138.00 in the year 1964-65. Purchased feed also increased by $9000.00 in the same period. In the last 2 years it has been necessary to supplement home grown feed with purchased hay from Washington State.

With so much activity concentrated on dairy production it is not surprising that there is little in the way of other activities. A beef activity, primarily a cow-calf operation is maintained as the only other commercial enterprise. The role of the beef herd on the farm has been one of diminishing importance. However, prior to the transfer of the dairy herd, beef cattle together with some hogs provided the sole means of income. The beef herd numbers remained fairly static for 1962-63 and 1963-1964 year but current plans call for a reduction to allow more dairy animals to be maintained. As mentioned already, the beef operation can be considered a cow-calf operation with calves being sold in the late fall. Very little finishing of animals is attempted.

This study is primarily concerned with the commercial aspects of the farming operation but to the extent that non-commercial objectives influence resource use they must be given some consideration. The non-commercial objectives are; to undertake research projects, to provide an opportunity for students to experience applied agricultural practices, to perform community services and to act in a demonstrational capacity.

The fulfillment of these objectives results in a resource use pattern that is quite different than it would be under a purely commercial operation. Experimental projects compete successfully for resources, particularly labour and land, reducing the amount available for more profitable alternatives. The result is that costs of operation are higher and output is reduced. The elite seed plots, the holly experiment and the role of the Ayrshire herd in a long term cross breeding experiment are cases in point. The elite seed plots and the holly experiment utilize land and labour that would otherwise be available for dairying. Similarly, the resources used by the Ayrshire herd could be utilized more profitably by Holstein cows or perhaps by some other activity.[3]

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3 This study has demonstrated the fact that the Holstein cow is more profitable than the Ayrshire. This conclusion is supported indirectly when one considers that less than 3% of all D.H.I.A. herds are of the Ayrshire breed.

SOILS ON THE FARM

The most noticeable characteristic of the soil types, particularly on the lower farm, is their complexity.[4] Their irregular boundaries transcend field boundaries so that any one field may have four to six soil types or sub-types. Despite this, soil and crop management problems have not been excessive. Drainage is, for the most part, more than adequate. This is one of the characteristics of the Chemainus type alluvial soils that are the most important. The Cassidy complex, the Qualicum series and the Neptune series are also present but are lower in productivity and generally coarser in texture ranging from loamy sand to stony loamy sand. Fortunately, these series occupy only a small area.

The upper farm is characterized by a series of benches that include most of these soil types (except the Neptune series). However the more productive Chemainus types occupy only a small area. Other areas are characterized by gravelly and stony deposits at or near the surface. The other soils appearing on the upper farm are the Bowser series and the Dashwood series. The Bowser series has been mapped into Bowser #1 and #2. Bowser #1 has, in general, a loamy sand texture and good drainage but only moderate (in relation to the other soils) productivity. Bowser #2 is poorly drained and of doubtful agricultural value. The Dashwood series has been classified as non arable due to the prevalence of rocks, boulders and stones.

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4 This discussion is based on an unpublished paper by K. J. Sleeman, Department of Soil Science, the University of British Columbia.

The productivity for forage production has been estimated at 2.5 tons of dry matter per acre on the lower farm and 0.75 tons on the upper farm. These were the productivity figures used in this study, representing the best judgement of those familiar with the area.

CROPPING AND FERTILIZER PROGRAMS

The principal forage mixture grown was one containing red clover, ladino clover, orchard grass, perennial rye grass and alta fescue with different fields having slightly different proportions.[5] One field contains alfalfa because experience has shown that it is the only field in which alfalfa does well. The forage mixture is under sown with oats and oat silage is harvested the first year. The forage stand remains for 4 to 5 years at which time it is ploughed and the cycle repeated. Pastures are clipped regularly and fertilizer is applied. Yields average 2.5 tons of dry matter per year with moisture being the main limitation on yields. In 1964, for example, yields were estimated at over 3 tons of dry matter per acre due to the favourable growing conditions.

Fertilizer application was heavier on the pasture fields than on fields used solely for silage or hay. The estimated rates (1964) were 252 lbs. per acre and 126 lbs. per acre respectively on the lower farm. No fertilizer was applied on

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5 See appendix 23 for forage mixtures

the top farm. This decision was based on the fact that, with limited funds, the fertilizer should be applied where it would bring the grestest return. Because pasturing is the most economical manner of utilizing forage, production was encouraged here.

THE ACCOUNTS

Accounts are presented for the fiscal years 1962-63, 1963-64 and for the calendar year 1964. A summary of the net worth for the three periods is presented in table I . Table II summarizes the operating statements for the three periods.[6]

The net worth statement is normally presented as part of the balance sheet representing on the liabilities side the owner's equity or the amount by which the farm business is indebted to the owner. On the Oyster River farm funds obtained for operating expenses and for capital investment are obtained via budget application and need not be repaid. As such, net worth is made up of all assets and it was sufficient to present only the statement of net worth. The increase in net worth from April 1, 1962 to December 31, 1964 was in excess of $15,000. Most of the increase is accounted for in the increase in livestock inventory occasioned by the objective of increasing the herd size. The remainder is made up of increases in machinery inventory and the value of creamery shares.[7] The decrease in value of building inventory caused by depreciation tends to hide the fact that building construction has been progressing over the past several years.

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6 Detailed inventories, valuation of assets, and operating statements are presented in appendices 1 - 6

7 Creamery shares represent a mandatory purchase of shares in the Comox Creamery Association. A levy of $ .05 per lb. of butterfat is deducted from the monthly milk cheque for this purpose.

The summary of operating statements shows a loss in each of the three periods. The 1964 statement shows considerable improvement over the other two but still shows a negative net farm income of over $10,000. It was necessary to modify the general ledger accounts to take proper account of changes in livestock inventory, farm consumed milk, and the classification of items of expenditure. The operating statement summary of Table II has been modified in this manner. A reconciliation of the 1964 modified statement with the general ledger statement of expenses and receipts and other details of calculation are presented in Appendix 6. The following section on financial measures of performance provides an analysis of the data in the net worth and operating statements.

TABLE I

SUMMARY OF NET WORTH

	1962 - 1963		1963 - 1964	1964 CALENDAR YEAR	
	Apr.1,1962	Mar.31,1963	Mar.31,1964	Jan.1,1964	Dec.31,1964
	$	$	$	$	$
LAND					
LOWER FARM	71,490.00	71,490.00	71,490.00	71,490.00	71,490.00
UPPER FARM	57,585.00	57,585.00	57,585.00	57,585.00	57,585.00
BUILDINGS	146,199.00	137,731.00	132,663.00	134,184.00	139,198.00
MACHINERY & EQUIPMENT	23,928.00	25,026.00	22,158.00	22,718.00	27,143.00
LIVESTOCK	41,503.00	45,596.00	45,610.00	45,537.00	54,970.00
FEED & SUPPLIES	1,000.00	1,000.00	1,000.00	900.00	3,200.00
CREAMERY SHARES	2,506.36	3,506.36	4,706.36	4,323.19	5,932.77
TOTAL	344,211.36	341,934.36	335,212.36	336,737.19	359,518.77

NOTE: See appendix 1 and 2 for the valuation of assets

TABLE II

OPERATING STATEMENT SUMMARY

	FISCAL YEAR 1962-1963	FISCAL YEAR 1963-1964	CALENDAR YEAR 1964
	$	$	$
TOTAL ADJUSTED INCOME	51,198.63	53,679.63	67,427.80
CASH EXPENSES	60,656.29	62,856.69	68,184.36
NON-CASH EXPENSES	10,175.77	9,446.84	9,992.76
NET FARM INCOME	- 19,633.43	- 18,623.90	- 10,749.32

FINANCIAL MEASURES OF PERFORMANCE

The choice of appropriate measures of performance was limited to those that promised to be the most useful and those that would yield valid comparisons with data from other studies ranging from 1959 - 1963. Consequently, measures relating to receipts and expenditures were made using averages of 1962-63 and 1963-64 data.[8] The sources of comparative data included the Vancouver Island Dairy study (1961) and the Fraser Valley study (1961) of the Economics Division, Canada Department of Agriculture.[9] In addition comparisons were made with two synthetic budget studies applying to Washington State, after certain data from these had been revised.[10] The measures derived from the American sources were used with some reservation since (1) they are derived from synthetic budgets rather than from an actual farm survey, and (2) different yield and management practices are postulated e.g. in one study milk production was assumed to be 14000 lbs. annually and all replacements were assumed purchased.

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8 See appendix 8 for the method of averaging and the method of allocating expenditures between the dairy and beef enterprises.

9 M.M. Sorboe and E.D. Woodward, Dairy Farming on Vancouver Island 1961. Vancouver, Economics Division, Canada Department of Agriculture, 1964; D.C. Crossfield and E.D. Woodward, Dairy Farming in the Fraser Valley of British Columbia 1961, Vancouver, Economics, Division, Canada Department of Agriculture, 1964

10 J.Swanson and B.J. Bond, Market Milk Production Costs, Pullman, Institute of Agricultural Sciences, Washington State University, 1959 (Stations circular 377); H. Parryman, H. Fletcher et al. Economics of Milk Production, Pullman, Agricultural Extension Service, Washington State University, 1962 ; Details of these revisions have been presented in appendices 7 and 8

The measures of performance that were calculated are presented in tables III and IV. The comparative position of the Oyster River farm may be summarized as follows:

Capital Investment per Cow

Capital investment per cow is substantially higher (except in the case of machinery) than for the other groups. Total investment per cow is about 50 per cent higher than in the other British Columbia studies. It is 2.0 to 2.5 times greater than in the Washington studies. Building investment per cow is 2.5 to 3 times greater than for the other groups. Machinery and equipment investment is lower at Oyster River due mainly to the fact that a considerable part of the powered equipment is rented. Much of the cause of the high total investment per cow lies in the large amount of non-arable land owned by the University. Since the farm was a gift to the University the apparent over-investment in land is not a point of valid criticism. There does, however, appear to be an over-investment in buildings. Even when one considers the necessity of more livestock shelter due to the high winter precipitation an investment per cow that is 2.5 to 3 times the average for otherwise similar conditions, does seem excessive.

Gross Revenue per Man Equivalent[11]

Gross revenue per man-equivalent is above average for the Fraser Valley and Vancouver Island studies, but below that of the high income groups of these areas. The very high figure

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11 A man equivalent may be defined as the availability of one man or his equivalent in terms of part time labour for one year.

TABLE III

MEASURES OF EFFICIENCY

	TOTAL INVESTMENT PER COW	BUILDING INVESTMENT PER COW	MACHINERY INVESTMENT PER COW	PERCENT QUOTA MILK	GROSS REVENUE PER MAN-EQUIVALENT
	$	$	$		$
OYSTER RIVER FARM	2,837.	1,070.	214.	73	7,227.
FRASER VALLEY HIGH INCOME GROUP	1,987.	315.	253.	87	8,688.
AVERAGE, ALL FARMS	2,103.	447.	251.	85	6,753.
VANCOUVER ISLAND HIGH INCOME GROUP	1,868.	380.	275.	85	7,074.
AVERAGE, ALL FARMS	2,203.	430.	298.	85	6,853.
WHATCOM COUNTY WASHINGTON	1,520.	347.	238.	N.A.	12,628.
GRAYS HARBOR & LEWIS COUNTIES WASHINGTON	1,114	321.	244.	N.A.	21,479.

NOTE: See appendices 7 and 8 for details of calculation.

TABLE IV

MEASURES OF EFFICIENCY

LBS. MILK PROD. PER COW	AVG. PRICE PER CWT. $	GROSS REVENUE PER COW $	GROSS REV. PER $100. CONC. FED $	LABOUR COST PER COW $	AVERAGE COST OF HIRED LABOUR PER MO. $	ANIMAL UNITS MAINTAINED PER COW	TOTAL CASH COST PER COW $	COST OF PRODUCING 100 LBS. MILK $
OYSTER RIVER FARM								
12,298	4.61	541.	368.	313.	325.	1.32	625.	7.18
FRASER VALLEY								
High Income Group								
9,969	4.39	615.	608.	158.	250.	1.26	410.	4.83
Average, All Farms								
9,507	4.28	548.	562.	200.	250.	1.25	457.	5.49
VANCOUVER ISLAND								
High Income Group								
9,537	5.04	610.	498.	199.	205.	1.29	468.	5.46
Average, All Farms								
8,860	4.94	588.	453.	211.	205.	1.27	492.	6.14
WHATCOM COUNTY								
Washington								
9,500	4.80	456.	513.	146.	288.	1.23	403.	5.58
GRAYS HARBOR & LEWIS COUNTIES								
Washington								
14,000	4.00	616.	587.	100.	394.	N.A.	401.	3.42

NOTE: See appendices 7 and 8 for details of calculation.

for the Gray's Harbor and Lewis Counties study is a result of (1) an assumed production of 14,000 lbs. annually and (2) very high labour utilization of about 2.2 man equivalents for 100 milking cows.

Gross Revenue per Cow

Gross revenue per cow is lower than the comparative B. C. groups but this may be attributable to a lower percentage of quota milk - 73 per cent vs. 85 to 87 per cent for the other B. C. groups. This must have been more than enough to offset the higher average prices received by Vancouver Island producers.

Gross Revenue per $100. Concentrate Fed

Gross revenue per $100. concentrate fed for the Oyster River farm is considerably below that of the other studies. As a measure of feeding efficiency it must be used with reservation because the quantity and quality of forage with which it is combined has not been specified. Nevertheless a return of $450. - $600. per $100. concentrate fed when compared to a return of $368. at Oyster River is not without meaning. Oyster River farm maintained a higher ratio of young stock per cow than did the others but this fact should have been offset by including increase in livestock inventory in gross revenue. The price of concentrate was about the same for all of the studies. The lower gross revenue per cow at Oyster River would account for only part of the difference. The one conclusion remaining is that more or better quality forage could profitably be substituted for some of the concentrate now being fed.

Labour Cost per Cow

Labour cost per cow is one-third to one-half higher at

Oyster River than the other B. C. groups and 2.5 to 3 times greater than the American studies indicate. It has been shown (table VII) that the number of animal units per man equivalent for Oyster River compared with Vancouver Island and the average for the Fraser Valley is about the same. The reason for the higher labour costs per cow is the higher wage rates paid employees at Oyster River (see table V). The low figures for the American studies are a result of lower wage rates and higher productivity per man.

Total Cash Costs per Cow

Total cash costs per cow, for the reasons outlined above are higher than for any other group and are higher than the gross revenue per cow. It is encouraging to note that for the calendar year 1964 the situation improved so that cash receipts and cash expenses were nearly equal.[12]

The Cost of Producing 100 lbs. of Milk

The cost of producing 100 lbs. of milk was calculated at $7.18 for Oyster River including the Dairy share of depreciation on buildings and equipment. The costs of production quoted in the other studies were modified to include the value of operator's labour. In addition the concept of cost of production used in the Fraser Valley study was not valid for comparison with Oyster River farm so it was necessary to recalculate the cost of production.[13] Details regarding the calculation of cost of production for the Vancouver Island group were omitted so the measure was recalculated. The discrepancy between the high

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12 See table II

13 D.C. Crossfield and E.D. Woodward, op. cit. page 19

cost at Oyster River and those of the comparative studies may be accounted for by reasons already discussed, namely, higher cash and non-cash expenses. Higher cash expenses may be attributed to higher wage rates, and higher feed concentrate costs. Above average investment in buildings results in higher depreciation charges. The cost of producing a hundredweight of milk is also a function of the amount of milk produced, and while Oyster River farm was above average in milk production, there were low producing cows that could have been profitably replaced with higher producers.

Machinery Utilization and Cost of Operation of Powered Equipment. [14]

The farm is fortunate in being able to lease 3 of its 5 tractors at a rate of 10 per cent of the new price per year. A manure spreader, forage blower and a front-end loader are also leased. Leasing, under these terms, is considerably less expensive than owning the machines because no charges for interest on investment or depreciation accrue directly to the farm. Tractors are kept about 2 years at which time they are replaced by a new one. The farm thus benefits by having newer equipment and fewer major repairs than might otherwise be the case.

An exploratory tractor utilization and cost of operation study was made with the following objectives in mind:

1. that such a study would pinpoint maximum use periods or "bottlenecks" in the farming operation. It would provide an indication of the possibility of smoothing the peak demand periods so that machinery and labour would be more efficiently used. In addition it would indicate the distribution of use between jobs.

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14 Machinery utilization is presented in this section as a logical prelude to costs of machinery operation

2. that is would provide an indirect measure of the distribution of labour requirements.

3. that it would provide a guide in breaking down the costs of various farm operations.

The procedure followed during the summer of 1964 was to record tractor hours at the end of each day and distribute this total to the tasks performed, according to the recollection of the operator. In addition tractor use records had been kept by Mr. W. Bourdillon, the farm mechanic, for 1961-62, so that an annual distribution was available. It was not feasible to attempt another full year's study. Instead, tractor use in the summer months was obtained by recording running hours for June, July and August. Winter month estimates were based on records for November and December.[15] Tractor utilization for 1962-63 is illustrated in figure 2. The most intensive use occurs in the months of May, June and July. Silage harvesting, haying and the mechanical feeding of dairy cows are the prime users of machine and man time. Of lesser importance are manure hauling, field work, fertilizer application and miscellaneous.

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15 The 1964 data are presented in appendix 9 and 10 since only five months of the year were studied. The pattern is similar to that of 1962-63 for which complete records were available.

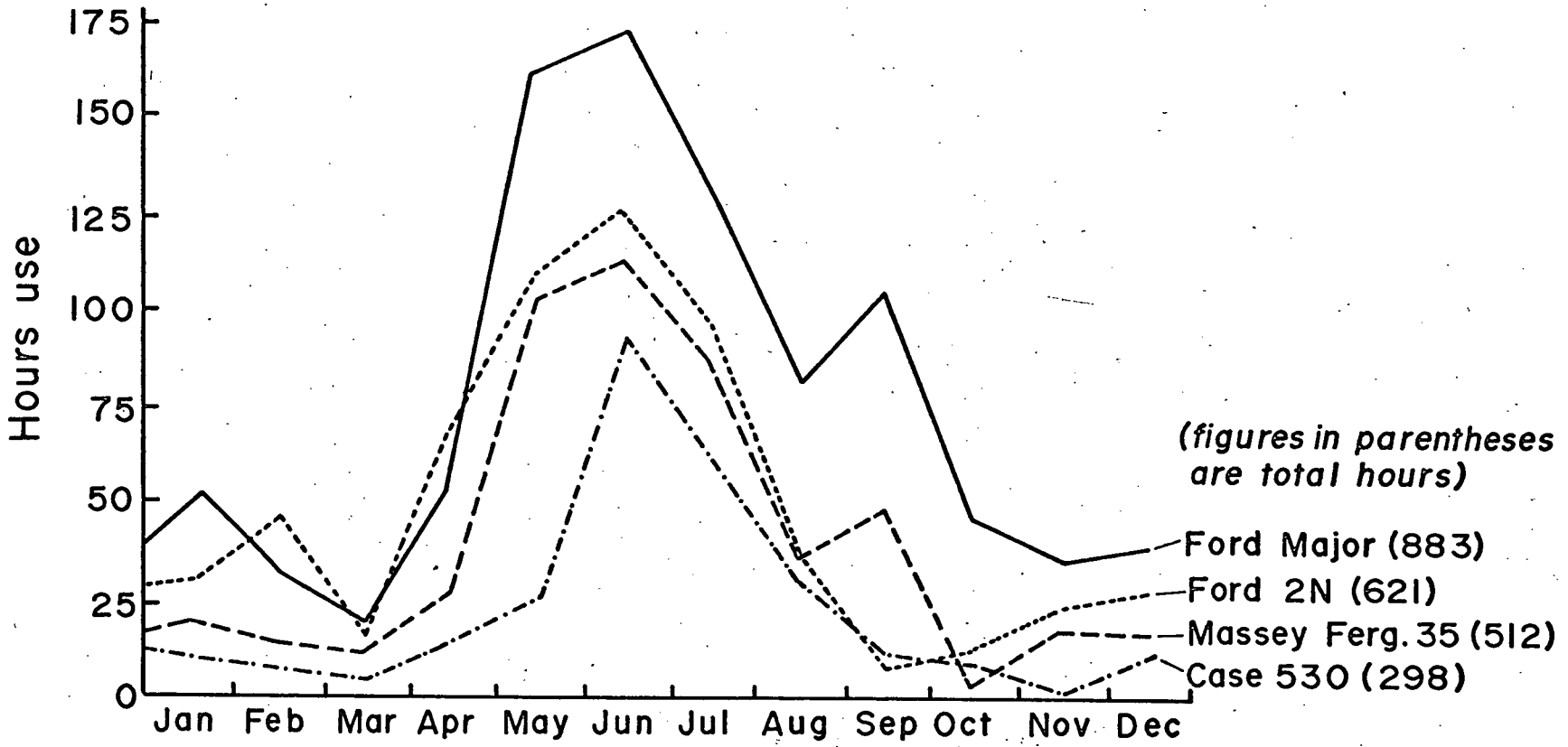

Figure 2. Tractor hours, monthly distribution, 1961–1962.

The Ford "Major" tractor is used more than any other, averaging 800 - 1000 hours per year. The Case "530" with the front-end loader is used least at about 300 hours per year. The other two wheeled tractors average 500 to 600 hours per year. The bulldozer was purchased in 1958 and was used extensively in the landclearing operations. Its present use is limited to odd jobs, (grading, snow removal etc.). Under the present use pattern replacement of this machine would not be economically justified. The 3-ton truck averages between 7000 and 8000 miles per year and the half-ton truck about 7000 miles. The disparity between summer and winter use in the case of the Ford "Major" averages 100 - 150 hours per month for the respective seasons, i.e. winter use is about 50 hours per month and June and July use averages 175 to about 200 hours per month. The other tractors follow a similar pattern.

The possibility of smoothing the distribution of tractor use is limited by the fact that most of the forage for silage (and for hay) is ready for cutting at the same time so that in order to preserve forage quality it must be harvested as rapidly as possible. One important factor is apparent in Figure 2 and that is the relatively low number of hours (during this peak period) spent by the Case "530" on the silage blower. One possibility of improving utilization would be to replace this tractor and blower with a silage elevator and electric motor. As a result, this tractor or its equivalent might be used to haul silage thus eliminating the waiting time presently incurred by the forage harvester. Alternatively, consideration could be given to eliminating the tractor (Case "530") from the

farming operation since it was used less than 300 hours per year and one-third of this time was for silage. A separate possibility would be to install a forage box on the 3-ton truck to provide a second vehicle for transporting forage. Two 8-hour shifts could be used to ensure that forage was harvested at peak quality. There is little that one can do to distribute the requirements of forage harvesting without sacrificing quality so the burden must rest on the best possible utilization of men and machines. Since the purpose of this section was exploratory in nature, detailed partial budgets showing the effects of these suggested changes have not been presented.

Costs of machinery operation were determined only for the powered equipment because they represent the most important segment of machinery costs. No attempt was made to determine the unit costs (per ton, per acre) of the various forage operations since these costs are affected by yield. However, such calculations could be made annually after the forage growing season when the yields are known. A summary of the costs of operation of powered equipment is made in Table V with details of calculation presented in Appendix 2.

TABLE V

COSTS OF OPERATION OF POWERED EQUIPMENT

ITEM OWNED EQUIP.	FIXED COST	VARIABLE COST per hr. or per mi.	EST. USE Hrs. or mi. per hr.	TOTAL COST or per mile
	$	$		$
3-ton Truck	890.40	.035/mi.	7000 miles	.162/mi.
half-ton Truck	438.50	.019/mi.	7000 miles	.082/mi.
Crawler Tractor	1353.40	.28 /hr.	N.A.	$7.04/hr.
Ford "2N"	152.60	.16 /hr.	500 hrs.	.458/hr.
LEASED EQUIPMENT				
Ford "Major" Diesel	448.27	.175/hr.	900 hrs.	.680/hr.
Case "530" Diesel	566.83	.209/hr.	300 hrs.	2.10/hr.
Massey Ferguson "35" Diesel	421.70	.150/hr.	500 Hr.	.99/hr.

NOTE: A record of hours of use was not available for the crawler. Cost per hour was calculated for 200 hours use.

MEASURES OF PHYSICAL PERFORMANCE

Milk Production per Cow.

The overall herd average of the cows at Oyster River for a 305 day lactation (1963 records) was 12,298 lbs.of milk with 432 lbs.of butterfat, or on a 4% fat corrected basis 11,399 lbs.[16] There was a significant difference in the production of each breed. On the average, each Holstein cow produced2622 lbs. of milk more than the average Ayrshire and 33 lbs. more fat. (Holsteins 13,406 lbs. milk,449 lbs. fat; Ayrshire 10,784 lbs. milk,416 lbs. fat). Data were obtained from D.H. I.A. route and herd averages for B.C. and Vancouver Island for comparison with the Oyster River herd. Table VI summarizes the results. Milk production at Oyster River, even with the composite herd, was higher than any of the other averages presented. Butterfat content, however, was below that of the other averages. No information was available for the amount of variation in the comparative herd averages, but it is significant that at Oyster River the range was between about 8000 lbs. and 18,500 lbs. The retention of the lower producers was predicated by the desire to build up the milk quota.

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16 Four per cent fat corrected milk was calculated using the following formula

$$4\%\ F.C.M. = 0.4\ (LBS.MILK) + 15.0\ (LBS.FAT)$$

TABLE VI

A COMPARISON OF AVERAGE MILK PRODUCTION PER COW

BREED OR AREA	NUMBER OF LACTATIONS	LBS. MILK	LBS FAT	PERCENT FAT
B.C.				
Holstein	11,936	11,799	444	3.76
Ayrshire	400	9,786	396	4.05
OYSTER RIVER				
Composite	71	12,298	432	3.51
Holstein	41	13,406	449	3.35
Ayrshire	30	10,784	416	3.85
VICTORIA	527	9,755	384	3.94
DUNCAN	635	10,615	430	4.05
NANAIMO	457	10,397	384	3.69
COURTENAY	658	10,669	422	3.95

SOURCE: (a) For British Columbia averages; British Columbia Department of Agriculture, Dairy Herd Improvement Services. Annual Summarized Report for 1962.

(b) For Vancouver Island averages; letter to the writer from Mr. J. A. Mace, Superintendent, D.H.I.A. Services, British Columbia Department of Agriculture, Victoria, B.C.

Forage Production per Acre

Since there have been no consistent attempts to measure forage productivity from the various fields the figure of 2.5 tons of dry matter used in this study is a judgment estimate. Spot checks that were made in the summer of 1964 indicate that the yield for that year was closer to 3 tons of dry matter per acre. However, the consensus of the manager and others in the area is that 2.5 tons of dry matter is a better long run average.

Even at 2.5 tons of dry matter per acre (or 2.8 tons of hay equivalent) gross output compares favourably with Fraser Valley yields averaging 2.17 tons of hay per acre[17] and Vancouver Island yields averaging 2.06 tons of hay per acre.[18]

The use of commercial fertilizer averaged 252 lbs. per acre on pasture and 126 lbs. on the remainder of the lower farm (predominantly ammonium phosphate, 16-20-0). In the Fraser Valley the average rate of application was 204 lbs. per acre with the high income group applying 228 lbs. per acre.

Labour Efficiency

The investigation of labor efficiency was limited to those areas of labor utilization that showed promise of yielding the most useful information. It should be recognized that estimates of Oyster River labour productivity are complicated by the non-commercial activities of the farm. The employment of students, for example, results in a lowering of average productivity.

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17 D.C. Crossfield and E.D. Woodward, Dairy Farming in the Fraser Valley 1961 op. cit. pp 12 - 13

18 M.M. Sorboe and E.D. Woodward, Dairy Farming on Vancouver Island 1961 op. cit. pp 13 - 14

Since the teaching objective of the farm is to enable students to gain experience, considerable time must be spent teaching cultural practices, feeding practices and machinery operation. When students rotate jobs to gain a wider variety of experience the job must be retaught. Experimental projects similarly affect labour utilization patterns. Farm maintenance at Oyster River must be kept at a consistently higher level than for non-institutional farms because the farm is supported by and open to the public.

Two general measures of physical efficiency were used in this study. In addition, a preliminary estimate of the number of cows milked per man hour (see Table VIII) indicated that a more detailed time study of this area would be fruitful and this was subsequently undertaken.

1. Productive man work units per man equivalent and animal units per man equivalent. [19]

Both measures are of an overall nature. The first is a measure that specifically includes the requirements for growing forage as well as livestock whereas the second emphasises the livestock requirements with forage growing requirements being implicit rather than explicit. The standards used were those of Sorboe and Woodward in the C.D.A. publication Dairy Farming on Vancouver Island (1961). They are the same coefficients that were used to define labour coefficients in a later part of this study.

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19 (a) A productive man work unit is the amount of work that can be accomplished by an average man in a 10 hr. day under average working conditions.
(b) Man equivalent has been defined in footnote 11.
(c) An animal unit (A.U.) refers to a feed consuming unit.

Calculation of the number of productive man work units at Oyster River (1964):

Livestock or Crop Unit (Average Numbers)		Work Unit Standards (10 hrs.)	Total Work Units
Dairy Cows	97	13.5	1309.5
Beef Cows	52	3.5	182.0
Heifers	31	2.0	62.0
	10	2.0	20.0
Calves	59	2.0	118.00
	5	2.0	10.00
Pasture Acres	188.6	0.61	115.00
Hay Acres	66.9	1.80	120.4
Silage Acres	163.0	2.50	167.5
TOTAL			2104.4

Calculation of the number of man equivalents:

Full-time employees [20]	Man Equivalents
Manager	0.5
Mechanic	1.0
Herdsman	3.0
Other	2.0
Summer help (Commercial part only)	
2 Students for four months	0.68
TOTAL	7.18

20 It has been estimated that one-half of the manager's time is available for the commercial activities on the farm with the other half being devoted to the teaching and research functions.

The number of productive man work units per man equivalent at Oyster River is therefore $\frac{2104.4}{7.18} = 293.10$

This compares favourably with the low and medium-income groups of the Fraser Valley at 277 and 255 work units per M.E. respectively. The high income Fraser Valley group was more efficient in the use of labor with each man performing an average of 340 work units per year. On Vancouver Island the work accomplished per man equivalent averaged 286, 297 and 275 for the high, medium and low income groups respectively. The Oyster River figure of 294.5 work units per man equivalent compares favourably with other Vancouver Island farms.

Animal Units per Man Equivalent

Comparisons using the number of animal units per man equivalent show a similar picture, with the Fraser Valley high income group having 23.21 animal units per man equivalent. Animal units per man equivalent average about 20 for Oyster River and other Fraser Valley and Vancouver Island calculations (see table VII).

These measures indicate that overall labour efficiency is above average for the area and for the Fraser Valley. This conclusion is even more satisfactory when one remembers that the commercial operation must bear the burden of some of the non-commercial objectives.

TABLE VII

AComparison of ANIMAL UNITS Maintained PER MAN EQUIVALENT

	AVERAGE NUMBER OF ANIMALS	ANIMAL UNIT STANDARD	AVERAGE NUMBER OF A.U.'S	MAN-EQUIV. EMPLOYED	A.U.'S PER MAN-EQUIV.
OYSTER RIVER DAIRY & BEEF					
COWS & BULLS	150.5		112.02*	-	-
HEIFERS	41.0	0.44	18.04	-	-
CALVES	64.0	0.25	16.00	-	-
TOTAL		-	146.06	7.18	20.17
VANCOUVER ISLAND (AVERAGE FARMS)					
COWS & BULLS	28.80	1.0	28.80	-	-
HEIFERS	12.30	0.44	5.41	-	-
CALVES	6.20	0.25	1.55	-	-
TOTAL		-	35.76	1.77	20.20
FRASER VALLEY (HIGH INCOME GROUP)					
COWS & BULLS	36.90	1.0	36.90	-	-
HEIFERS	16.10	0.44	7.08	-	-
CALVES	9.10	0.25	2.27	-	-
TOTAL		-	46.25	1.91	24.21

SOURCE: (a) Vancouver Island; M. M. Sorboe and E.D. Woodward Dairy Farming on Vancouver Island 1961 op. cit. pp 18 - 19

(b) Fraser Valley; D.C. Crossfield and E.D. Woodward, Dairy Farming in the Fraser Valley. 1961 op. cit. pp 16 - 18

* A.U.'s have been standardized to allow for the difference in labour requirements of dairy and beef animals.

In considering these measures one must bear in mind two important qualifications. The first is that performance rates equal to or better than those in the area do not necessarily mean that labour efficiency cannot be further improved. A particular example comes to mind in the hand feeding of silage during the winter months. Under the present system silage must be forked from the silo by hand, then distributed by hand from a tractor drawn trailer. Relocation of the silos to facilitate the transfer of an automatic unloading device from one to another plus a feed conveyor belt at the bottom are future improvements that would increase labour efficiency. The second qualification is that measures of overall efficiency tend to mask areas of inefficiency. The milking parlor is a case in point. Preliminary examination of the number of cows milked per man hour indicated that Oyster River performance was about two-thirds of what one could expect with a stanchion type barn. Accordingly a time study was set up to ascertain the areas of the milking routine that required improvement.

The Milking Parlor Time Study

Method:

Two stop watches were used in timing the operation of the milkers. Both watches were started at the moment a cow entered the milking parlor. One watch was left running (to provide a check) until the machine had been removed from the cow. The other watch was used to time various operations using the snap-back technique. The operations were grouped so that starting and finishing points were as well defined as possible. An attempt was made to distinguish between necessary operations and

TABLE VIII

MEASURES OF MILKING EFFICIENCY

	STANCHION BARN	DOUBLE -3 TANDEM WALK THROUGH	DOUBLE-4 HERRING BONE	OYSTER RIVER FARM
COWS PER MAN HOUR	30	32	43	14
MAN MINUTES PER COW	2.00	1.88	1.40	4.21
MACHINE ON TIME PER COW	5.50	5.50	5.50	6.69
MACHINE OFF TIME PER COW	.32	.14	.14	1.13
IDLE MACHINE TIME PER CENT	5.5	2.5	2.5	16.9

SOURCE: Data was obtained from the U.S.D.A. publication The Farm Cost Situation May 1959 as presented in the Dairyman's Guide Book, published by the Chore Boy Manufacturing Co. of Cambridge City, Indiana.

those that were performed while essentially waiting for the cow to be milked. Since a complete time and motion study was beyond the scope of this study no attempt was made to test the results statistically. The results are presented in tabular form in Tables VIII and IX, together with standards derived by McHardy and by the U.S.D.A.[21] McHardy used a motion picture camera to record and time individual operations. The times for the operations that were relevant to the Oyster River operation were summed for comparison with the group times obtained using the stop watch.

The milking parlor was designed to handle four cows in tandem on either side of an operator's pit. Until recently only one side of the milking area has been used and it was under these conditions that the time data were collected. At this writing two additional stalls are being completed on the other side of the operator's pit, that should have the effect of increasing the milking rate. Two men perform the milking operation.

It was found that the principle reason for the low number of cows milked per man-hour was the relatively idle period while waiting for the cows to be milked out. The interval between the time a machine was installed on a particular cow and the time it was removed averaged 6.69 minutes. During this time only

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21 F.V.McHardy, "Standard Time Data For Side Entering and Herringbone Milking Parlors", Agricultural Materials Handling Manual Section I.I, Ottawa National Coordinating Committee on Agricultural Services, Canada Department of Agriculture, Queens Printer, 1962, page 35;
M.M. Lindsey, Farm Economics Research Division, Agricultural Research Service, U.S.Department of Agriculture, The Farm Cost Situation, May 1959, cited in Chore-Boy Manufacturing Company Inc., Dairyman's Guide Book for Profitable Dairying, Cambridge City, Indiana, pp. 12 - 13

one other cow had to be prepared, requiring 1.10 minutes. The operator also spent an average of 1.09 minutes on each of the two cows that he was responsible for, machine stripping, massaging udders and checking his cows. The 3.50 minutes remaining before the initial cow had been milked was essentially idle and could have been used to handle at least one more cow.[22]

The above calculations were based on the present rates of performance at Oyster River. Faster rates of work would also increase the capacity of the milking parlor. The rate at which a cow can be milked is another factor. Some cows can be milked out in less than 4 minutes while others may take over 10. These two factors were apparent in the Oyster River study. Cow preparation time, for example, averaged 1.10 minutes per cow compared to the McHardy standard for the same group of operations of 0.733 minutes. Cow milk out time averaged 1.19 minutes per cow longer than the U.S. D.A. standard (6.69 vs 5.50). Another manifestation of the low milking rate was the high percentage of idle machine time between cows. Idle machine time averaged 1.13 minutes per cow or 16.9 per cent of machine-on time compared to U.S. D. A. standards of 2.5 - 5%. Much of this is due to the type of equipment, for example the rollo-measure takes about 1 minute to empty depending on the amount of milk in it.

The Organization of Farm Records

A good system of farm records will include both physical and financial records. The particular form of these records will depend on the use to which they will be put and the objectives of the farm. In the case of a commercial farm the charac-

22 In general the operator appeared busy during most of this interval but the work performed was non-essential.

TABLE IX

A COMPARISON OF OPERATION TIMES
FOR A SIDE ENTERING WALK THROUGH
MILKING PARLOR

OPERATION	McHARDY STANDARD MINUTES	OYSTER RIVER MINUTES
1. PREPARE COW		
Close Tailgate	.040	
Wash Cow (Hose)	.087	
Wash Cow (Rag)	.120	
Dry Udder	.112	
Strip Check (Cup)	.137	
Right Rollo-Measure	.036	
Install Machine	.201	
TOTAL	.733	1.10
2. MASSAGE UDDER, MACHINE STRIP, CHECK COWS	N.A.	1.09
3. MACHINE IDLE TIME (AFTER REMOVAL OF MACHINE)		
Dump Rollo-Measure	.024	
Record Weight	.090	
Walk (10 steps at .012)	.120	
Open Headgate	.025	
Close Headgate	.036	
Open Tailgate	.040	
Feed (Crank)	.013	
Hold Door Open	.124	
Milk Emptying	N.A.	
TOTAL	.472	1.13

SOURCE: F.V. McHardy "Standard Time Data for Side Entering and Herringbone Milking Parlors. Agricultural Materials Handling Manual Section 1.1 op. cit.

teristics have been well defined. Hopkins and Heady state that the objective of farm records and accounts is "to facilitate the management of the farm".[23] They go on to suggest the following ways in which management benefits from accurate farm records:

1. By providing a history of performance including both physical performance and financial performance.
2. As an aid in the control of current operations.
3. Provision of the basic information for budgeting or planning farm operations.

Adequate farm records are typically composed of three parts: (1) Farm inventory taken annually (or more frequently), (2) Accounts dealing with receipts and expenditures and (3) Physical production records that provide basic input-output data. If the objective of the Oyster River farm is to operate on a commercial basis consistent with the attainment of its other objectives then the present system of record keeping is inadequate.

At present the record keeping system is composed of the accounts, daily milk production records and a weekly inventory of livestock. The accounts are adequate in that all cash expenditures and receipts are recorded on a monthly statement. However from the point of view of analysis an accounting for non cash expenditures and receipts should be included on an annual basis. The classification of the expense accounts could be improved so that similar items and items pertaining to the

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23 John A. Hopkins and Earl O. Heady, Farm Records and Accounts, Ames, Iowa, The Iowa State College Press, 1955. pp. 4 - 5.

same enterprise were grouped together.[24] The largest criticism of the present system is the general absence of physical records. Although milk production records are kept with painstaking care little or no effort is expended in determining the feed (or other inputs) consumed in producing the milk. Records of land utilization, crop yields and beef production records are similarly non-existent. Furthermore, the present method of accounting control does not appear to be sufficiently flexible to take advantage of unforseen opportunities and to take proper account of unforseen expenses. Estimates of receipts and expenditure must be made one year in advance and the management appears committed to staying within individual account budgets. Proper accounting control is necessary for any business but it should not unduly hamper decision making. A partial solution would be to make formal provision for a quarterly revision. The following changes would alleviate the shortcomings of the present system of records.

1. An annual inventory should be taken of all assets including such items as the amount of feed, fuel, and fertilizer on hand.
2. If a suitable method of control can be devised individual feed records for each cow should be kept to complement existing individual production records. Monthly estimates (by weighing) of hay and silage should be kept and reconciled with inventories.

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24. For example, in preparing the operating statements for this study it was often necessary to trace original documents to verify expenditure items. A suggested reclassification is presented in Appendix 12

3. A system of crop records should be devised that would indicate land utilization, soil preparation and treatment, crop mix grown, fertilizer and manure application and yields. Also, some general comments re: seasonal abnormalities should be included.

4. Production records of the beef enterprise should indicate lbs. of beef produced per unit of feed input or value of beef produced per dollar of feed input.

5. The financial records are complete in that all cash expenditures and receipts are recorded but a re-organization of items as suggested in Appendix 12 would facilitate economic analysis and interpretation.

6. If consideration is to be given to commercial objectives then the farm operations accounts should be quite distinct from the accounts dealing with teaching and research projects.[25]

Research projects might be handled best by including in the project budget an estimate of the farm "out-of-pocket" expenses and the farm operations accounts would be reimbursed for this amount.

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25. An attempt is made to separate the teaching and research accounts from the commercial accounts but it is only partially successful.
Farm "out-of-pocket" expenses incurred while undertaking research projects have in some cases been absorbed by the farm. The same is true of visiting and travelling expenses incurred on non-commercial business.

6. Expenses that would occur with or without the project could be absorbed by the farm.
7. Where specific research projects are not involved but where a teaching or community service (eg. the elite seed plots) are involved farm expenditures should be handled on a budget basis and included only under the teaching and research accounts.
8. Expenditures incurred while guests are staying on the farm and non-commercial travelling expenses should be covered by an account in the teaching and research section.
9. Capital expenditures should be quite distinct from both the commercial operation and the teaching and research function.

These recommendations presuppose that both the physical and financial records will be used by the management in evaluating the performance of the farm. In addition it is suggested that such assessment should lead to planning for improvement. Obviously records are of little value if they are not employed in a dynamic manner.

CHAPTER III

THE NORMATIVE ANALYSIS

Since this study is concerned with the practical application of linear programming to a farm management problem, the conclusions and their underlying assumptions and limitations are more relevant than a detailed account of the theory of linear programming.[26] It will suffice to present the profit maximizing problem and to state the underlying assumptions and limitations. The calculation of technical coefficients is, however, presented in some detail because of its importance in obtaining meaningful results. Heady and Candler state:[27]

> "The most difficult task in setting up forms for a linear programming problem is to obtain meaningful technical coefficients. The need for care and detail in this respect should be reemphasized. Additional effort in this direction generally is more important than in additional refinements in the mathematical approach."

The Linear Programming Problem and It's Assumptions

The linear programming problem dealt with in this study was to maximize profit subject to the restrictions of a set of linear inequalities. In matrix notation the problem may be stated as follows:

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26 For a detailed account of agricultural applications of linear programming see
E.O. Heady and W. Candler, Linear Programming methods, Ames, Iowa, The Iowa State University Press, 1958.

27 Ibid., pp. 225.

Maximize the objective function;[28] $f(X) = C'X$

Subject to the retrictions;

$$PX \leq S$$

$$X \geq 0$$

Where C' is a transposed column vector of net prices.

$$C' = \begin{bmatrix} c_1 & c_2 & c_3 & \cdots & c_j \end{bmatrix}$$

X is a column vector of production possibilities

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ \cdot \\ x_j \end{bmatrix}$$

p is the matrix of technical coefficients of the activities in X.

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1j} \\ p_{21} & p_{22} & \cdots & p_{2j} \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \\ p_{m1} & p_{m2} & \cdots & p_{mj} \end{bmatrix}$$

S is the column vector of resource supplies;

$$S = \begin{bmatrix} s_1 \\ s_2 \\ \cdot \\ \cdot \\ \cdot \\ s_m \end{bmatrix}$$

and 0 is a null matrix j by 1

The above formulation of the problem would be satisfactory if it could be ascertained that the resources would be completely exhausted. The introduction of disposal activities permits non-use of resources and changes the restriction dealing with resource

28 The objective function is the profit function to be maximized. It will subsequently be referred to as the functional.

supplies from

$$P \; X \leq S$$

to

$$P \; X = S$$

Where $P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1j} & 1 & 0 & 0 & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2j} & 0 & 1 & 0 & \cdots & p_{2n} \\ \cdot & & & & & & & & \\ \cdot & & & & & & & & \\ p_{m1} & p_{m2} & \cdots & p_{mj} & 0 & 0 & 0 & \cdots & 1 \end{bmatrix}$

and $X = \begin{bmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ \cdot \\ x_n \end{bmatrix}$

The inequality $X \geq 0$ still holds.

The C vector must also be enlarged to n prices.

Programs that meet the restrictions $P X = S$ and $X \geq 0$ are feasible programs. An optimum program is one that is feasible and at the same time maximizes the functional $f(X) = C'X$.

The simplex method of maximizing the functional starts with an initial feasible program in which all resource supplies are allocated to disposal. Then, using an iterative process, real activities are brought in to the program one at a time until the functional has been maximized. A criterion equation is employed to determine which of the real activities will add most to profit. The criterion equation is of the form

$$Z_j - C_j \quad \text{where the } Z_j \text{ is } \sum_{i=1}^{m} C_i r_{ij}$$

or the sum over all elements of column j of the products of the

prices of the activities (or resources) in the plan and the coefficients in column j. C_j is the price of the activity represented by column j.[29] The r_{ij} is the marginal rate of substitution of the i th resource or activity with the j th activity. After the first iteration the marginal rate of substitution is expressed in terms of the most limiting resource. When the r_{ij} are multiplied by their respective prices C_i and the product summed over all elements in column j the result is the opportunity cost of adding one unit of the activity represented by column j. If the price of this activity, C_j is greater than the opportunity cost ($Z_j - C_j < 0$) then profit will be increased by adding the j th activity to the program and completely replacing the resource that was most limiting. When more than one activity has a negative $Z_j - C_j$ the activity with the most negative value is the one that enters. The iterative process continues until all $Z_j - C_j \geq 0$.

The Assumptions in Linear Programming

The assumptions in linear programming fall under four headings.

1. Additivity and Linearity. The total quantity of a factor used must be the sum of its individual uses and total product must equal the sum of all individual products. The output-input ratio is constant for individual activities and for all activities considered together hence only constant returns to factor input and constant returns to scale are permitted. Interaction effects are not generally accounted for.

29 The term 'price' refers to the net price or return to fixed factors of production. Unless otherwise specified or implied this will be the meaning in the discussions that follow.

2. Divisibility. This assumption implies that factors and units of output can be used or produced in quantities that are infinitely divisible. It does not recognize the "lumpiness" that sometimes occurs when adding factors of production.
3. Finiteness. It is assumed that there is a limit to the number of activities and resource restrictions that need be considered.
4. Single value expectations. The implications of this assumption are that prices and technical coefficients are known with certainty.

The assumptions under which the linear programming model is set up are not as restrictive as they might appear. The assumption of additivity and linearity will not in general be limiting. Interaction occurs infrequently and returns to scale in dairy farming appear to be constant.[30] The assumption of divisibility of factors and output need not be serious. Using an appropriate choice of units of input and output, quantities called for in the optimum plan can be rounded to the nearest unit without serious error.

The assumption of finiteness is a very practical one. The choice of activities from which the optimum program might be selected was limited to those that appeared to offer the greatest chance of success. The choice of resource restrictions was

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30. See, for example, E.L. Menzie, O. Klassen and F. VanAndel. Dairy Farm Management Manual, British Columbia Department of Agriculture and U.B.C. Department of Agricultural Economics pp. 46-48. The expected operator's labour earnings are nearly proportional to the size of operation as measured by the number of milking cows.

limited to those that appeared to be most critical in determining the production patterns.

The assumption of single value expectations for activity prices was approached with some reservations, especially in the case of potatoes. It was for this reason that tests were made to determine the ranges of price stability for activities recommended in the optimum solutions.

Having discussed the algebraic formulation of the problem and the underlying assumptions the next step was to select the alternative activities and to define the relevant technical coefficients and net prices.

The Selection of Alternative Activities

The greatest number of activities center around the dairy activities. The rationale of this decision is that dairying is the predominant commercial farming activity in the area and the fact that the Oyster River farm is substantially committed to a dairy operation. The predominant type of farming in an area is a valuable guide in determining the activities that are likely to be the most profitable. Considering this fact and the resources already committed to dairying the decision was made to define a number of dairy activities. Both the Holstein and Ayrshire breeds are represented at Oyster River so the dairy activities include representations of each breed.

The choice of other activities was conditioned by their potential profitability compared to dairying, their demand for additional resources, the market for the product, and the activities other than dairying that are part of the present operation. The final choice was narrowed to two beef activities (cow-calf and a

cow-yearling operations) one potato activity, one sheep activity and purchasing activities for labour and hay. Beef was considered because it is part of the present operation. A sheep activity was included because of the possibility of more effectively utilizing the upper farm area. The potato activity was included with some reservations. On the one hand potatoes appeared to offer a more profitable alternative to dairying than either beef or sheep, and also that potatoes have been grown successfully on the farm and are grown successfully in the area. On the other hand there is an initial barrier to new growers marketing their product and furthermore new buildings and equipment would be required. The problem of new investment can be handled quite readily by incorporating its cost, in the form of depreciation and interest on investment in the calculation of net prices.[31] The marketing problem for potatoes is more difficult. Marketing is controlled through the Courtenay plant of the B.C. Coast Vegetable Marketing board. New growers are assigned a marketing quota of four tons in each of the three marketing categories; earlies, second earlies, and late potatoes. A new grower would have to operate on a small scale initially until his marketing quota increased.[32] Despite these limitations it was decided to include a potato activity based on an established and stable (with respect to size) operation in order to validly compare it with other established operations. A second reason for including potatoes was

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31 Heady and Candler, op. cit. pp. 219 - 220

32 Marketing quotas will revolve at least twice and perhaps as many as twelve times in one year. Quotas are based on a grower's performance over the past five years. A new grower could increase his quota by one-fifth of the quantity marketed the previous year.

that if they should displace part of the dairy activities (as in fact they did) it would provide an indication of the profitability required of any other activity to displace dairying in the future. A purchasing activity was defined for hay buying that had the effect of adding to the supply of land. Labour purchasing was considered under two separate analyses. In one, labour purchasing was restricted to the months of May, June, July, August, and September; in the other, labour purchases were permitted for all periods.

Preliminary consideration was given to hog, poultry, strawberry and tree fruit production. Hogs were rejected because all feed would have to be purchased and because of the adverse effect on profit, of transportation charges of feed to the farm and the finished product to Vancouver. Also, earlier experience with hogs was not satisfactory. Omission of hogs was supported in correspondence with the local district agriculturist, who also advised against strawberry production because of the very limited local market. Poultry production was rejected because of the capital investment and specialized management required and the fact that resulting profit did not appear to be higher than for the already established dairy operation. Tree fruit production was rejected because of the limited local market and the long waiting period before production begins.

Defining the Activities and Resource Restrictions.

Two fundamental approaches were used in defining the activities. One involved the use of production functions and the other the use of regional and budget studies. The use of production functions in defining activities is the more desirable

approach in that it is a closer approximation to the concept of defining production possibilities, whereas budget studies are typically based on just one point of the production function. The use of production functions, however, is limited by those that are available, their relevance for the area under study and the units in which they are defined. It was feasible to define some dairy coefficients using production functions while other coefficients were defined using regional and budget studies together with publications containing physical requirements for livestock. The beef, sheep and potato activities were defined using budget studies, due primarily to the limited availability of suitable production functions. The resource restrictions used in this study were: land, labour (for nine periods in the year), building space and operating capital, totalling fourteen restrictions.

The problem of defining resource restrictions for land and buildings is straight forward. The correct number of labour restrictions depends on the periods of the year when it is most limiting. The winter months from November to the end of February were aggregated to form one period. The remaining months were defined separately because of the difficulty of determining *a priori* which was likely to be the most limiting. An operating capital restriction was included primarily to facilitate specification of capital requirements under the optimum programs.[33]

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33 The level at which capital is restricted is somewhat indeterminate in that the supply depends on budget approval by the University authorities.

The Dairy Activities

The first step in the consideration of an enterprise is to define the producing unit. Technical coefficients, value of output and net prices are then determined with respect to the producing unit. In the case of the dairy activities the producing unit was defined to be one cow plus her supporting young stock. The calculation of a normal complement of young stock was based on a herd of 70 milking cows and a cull rate of 20%. It has been calculated that in order to maintain 70 milking cows (on a 305 day lactation) a herd of 82 cows would be required.[34] Assuming a cull rate of 20% 17 replacements would be required annually. It was further assumed that all replacements were farm raised and that 25 bred heifers would be maintained in order to allow some choice in the selection of the 17 replacements. Given a 50% heifer calf crop and a death or failure to calf loss of 4 animals, 38 heifer calves would be born each year. Of these, 13 could safely be sold at birth. An excess of replacement stock remains, but may be justified as a guard against unforseen losses. As it becomes apparent that some bred heifers will not be needed as replacements they are assumed to be sold. In addition it was assumed that two of the better bull calves would be kept each year and sold for breeding purposes at about 18 months of age.

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34 Seventy cows producing for one year can be expressed as (70) (12) or 840 cow producing months. However on a 305 day lactation the number of cow producing months is (70)(10) or 700. Therefore to maintain a constant level of 70 milking cows $\frac{840 - 700}{12} = 11.6$ or 12 additional cows would be required.

Following from the above reasoning the cow and her supporting young stock were calculated as follows:

COW		1.0 animal
Heifer calves (avg. age 6 mos.)	$\frac{26.5}{82}$	.323 animal
Bred Heifers (avg. age 20 mos.)	$\frac{20}{82}$	.244 animal
Bull Calves[35] (avg. age 1 yr.)	$\frac{2}{82}$	.024 animal

These calculations are based on an average ratio of cows to replacement stock, the average being calculated between the actual replacements needed and the number of each age group maintained to allow more choice in selecting the final replacements. For some of the calculations it was convenient to express the production unit in terms of feed consuming animal units as follows.[36]

1 Cow	1.0 animal unit
1 Heifer (1-2 years)	.44 animal unit
1 Bull (1-2 years)	.44 animal unit
1 Calf (under 1 year)	.25 animal unit

The number of animal units in the production unit are

1 Cow	1.0 animal unit
.323 calves @ .25 animal unit	.081 animal unit
.244 bred heifer @ .44 animal unit	.107
.024 bull @ .44 animal unit	.011
TOTAL ANIMAL UNITS	1.199

35 These animals were included at the suggestion of the farm manager in the belief that they could profitably be sold as breeding stock at about 18 months of age

36 These standards have been used by the Economics Division Canada Department of Agriculture, Vancouver

Technical Coefficients for Dairy Activities

Two approaches were considered to define technical coefficients for dairy activities.

1) The use of budget studies and regional averages.
2) The use of milk production functions including the use of the Missouri Partition Equation - a physiological equation expressing a functional relationship between T.D.N. input, milk output and body weight.[37]

It is postulated that the most logical basis for defining the land requirements for dairy activities is on the basis of different combinations of forage and concentrate that will produce a given quantity of milk. With this basis, resource requirements for land (to grow forage), operating capital (to purchase feed) and labour will differ. Building requirements will remain the same for all activities. The rationale for this method of definition is that optimal plans that include one or more of these activities would be easily implemented in the short run. Activities based on different types of buildings and machinery, for example, might require substantial reorganization of the farm and/or substantial capital outlays. In view of the fact that the farm is already committed, within fairly narrow limits, to a particular type of dairy operation, coefficients based on a knowledge of the substitution rates between forage and concentrate are more practicable.

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37 Samuel Brody, Bioenergetics and Growth New York, Reinhold Publishing Corporation, 1945.
T.D.N. annual = .305 (4% F.C.M.) + $(0.053W^{.73})365$ + 2.1ΔW
Where T.D.N. is total digestible nutrients, F.C.M. is fat corrected milk and W is body weight of the animal.

It is in this latter respect that the use of budget studies and regional averages is restrictive. Most of these studies stipulate certain feed requirements for some average quantity of milk output leaving little or no room for the substitution of one feed for another. Input-output data are based on an "average cow" in the herd so that there is no specification for cows of different inherent ability. The use of production functions, on the other hand, achieves a more comprehensive specification of input-output relationships.

The Production of Function Approach

Ideally a function derived locally is one that is best suited since it holds relatively constant the effect of environmental conditions. The derivation of such a function was beyond the scope of this study so it was necessary to utilize functions derived by others. The choice of an appropriate function was conditioned by four factors: (1) the functions that were available, (2) the appropriateness of those that were available in satisfactorily representing known physiological characteristics of milk production, (3) the adaptability to the Oyster River farm of functions derived in other areas and (4) the ability to represent both the Holstein and Ayrshire breeds.

Consideration was given to functions derived by Kerr[38] based

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38 T.C.Kerr, The Use and Scope of Dairy Herd Improvement Association Data in Estimating the Functional Relationship Between Feed Input and Milk Output For Dairy Cows, Unpublished B.S.A. essay, The University of British Columbia, 1963.

on Fraser Valley data, functions derived by Gossling[39] based on Ontario data and an experimental function derived by Heady et al.[40] Comparison of the isoquants derived from these functions with those derived using the Missouri partition equation indicated that the former functions were subject to the criticism of not specifying sufficient Total Digestible Nutrients for the maintenance of body weight and production.[41] After consultation with the Animal Husbandry Department at U.B.C. the Missouri partition equation was chosen as the basis for defining the dairy activities. Isoquants derived from this equation and representing both the Holstein and Ayrshire breeds are shown in figures 3 and 4. The choice of points representing different combinations of forage and concentrate was somewhat arbitrary. The general location of such points is biased in favour of rations with larger quantities of forage. This was because with linear isoquants and a price ratio of concentrate to forage almost always greater than 1, the least cost ration will have a maximum of forage and a minimum of concentrate. For physiological reasons some concentrate must be fed and this minimum was set at 3.25 lbs. of T.D.N. per day. For

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39 W.F. Gossling, "The Economics of the Holstein-Friesian Cow", Journal of Agricultural Economics, vol. XV, no. 4, December 1963.

W.F. Gossling, "The Ontario Short Run Milk Supply Curve", Canadian Journal of Agricultural Economics, vol.XII, no.1

40 E.O.Heady, J.A.Schnittker, N.L.Jacobson and S.Bloom, Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations, Agricultural Experimental Station, Iowa State College, Ames, October 1956, (Research Bulletin 444).

41 See appendix 13 for a comparison of production functions.

the same reason the forage minimum was set at 5.1 lbs. T.D.N. daily. The combinations of forage and concentrate defining the activities are shown in appendix 14. Nineteen activities were originally defined in this manner for isoquants ranging from 25 lbs. of 4% F.C.M. to 50 lbs. of 4% F.C.M. per day. Subsequently the four lower producing activities were dropped when it was discovered that they had negative net prices.

Total T.D.N. requirements (see figure 3) for an average Ayrshire cow under stipulated levels of output are as follows:

Daily T.D.N. Requirements Annual basis. LBS.	Daily Output of 4% F.C.M. 305 day Lactation basis. LBS.
14.45	25.0
17.70	35.0
19.00	40.0
20.30	45.0

Body weight of the animal was assumed to average 1100 lbs., taking into account some loss of weight during lactation and subsequent recovery during the dry period. The method was also used to represent an average Holstein cow except that an average weight of 1300 lbs. was used. Total T.D.N. requirements (see figure 4) for stipulated levels of output are:

Daily T.D.N. Requirements Annual basis LBS.	Daily Output 4% F.C.M. 305 days Lactation basis LBS.
19.0	35.0
21.5	45.0
22.5	50.0

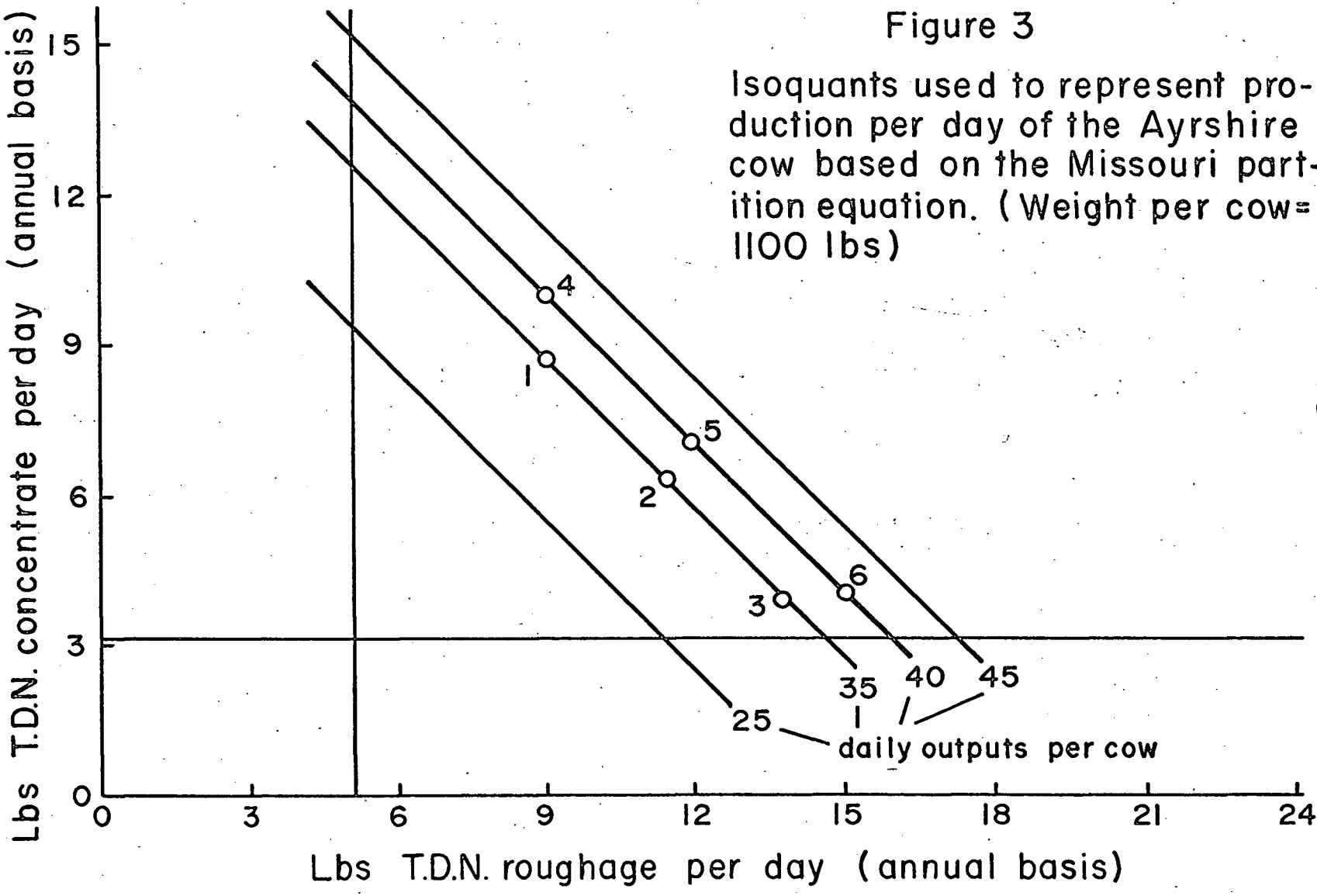

Figure 3

Isoquants used to represent production per day of the Ayrshire cow based on the Missouri partition equation. (Weight per cow= 1100 lbs)

The selected points on the isoquants of figures 3 and 4 were used to calculate land coefficients. The amount of forage T.D.N. specified at each point was converted to actual lbs. of forage (assuming forage contains 50% T.D.N.) and multiplied by 365 days. To this was added the annual requirements of the supporting stock. This total was then divided by 2000 lbs. times a yield of 2.8 tons of hay equivalent per acre to arrive at the land coefficient for each dairy activity. The land coefficients are presented in Table X. The points in figures 3 and 4 were used in calculating the feed cost for inclusion as part of the operating capital coefficients. They also proved useful in partially defining the labour requirements.

TABLE X

LAND COEFFICIENTS FOR THE DAIRY ACTIVITIES

ACTIVITY	ACRES	ACTIVITY	ACRES
A_1	1.134	A_9	2.122
A_2	1.653	A_{10}	1.083
A_3	1.966	A_{11}	1.640
A_4	1.340	A_{12}	2.122
A_5	1.731	A_{13}	1.340
A_6	2.122	A_{14}	1.731
A_7	1.340	A_{15}	2.122
A_8	1.731		

Other Resource Requirements

Although the production function approach proved useful in defining land requirements by way of forage inputs and partially defining labour requirements, it was necessary to seek other

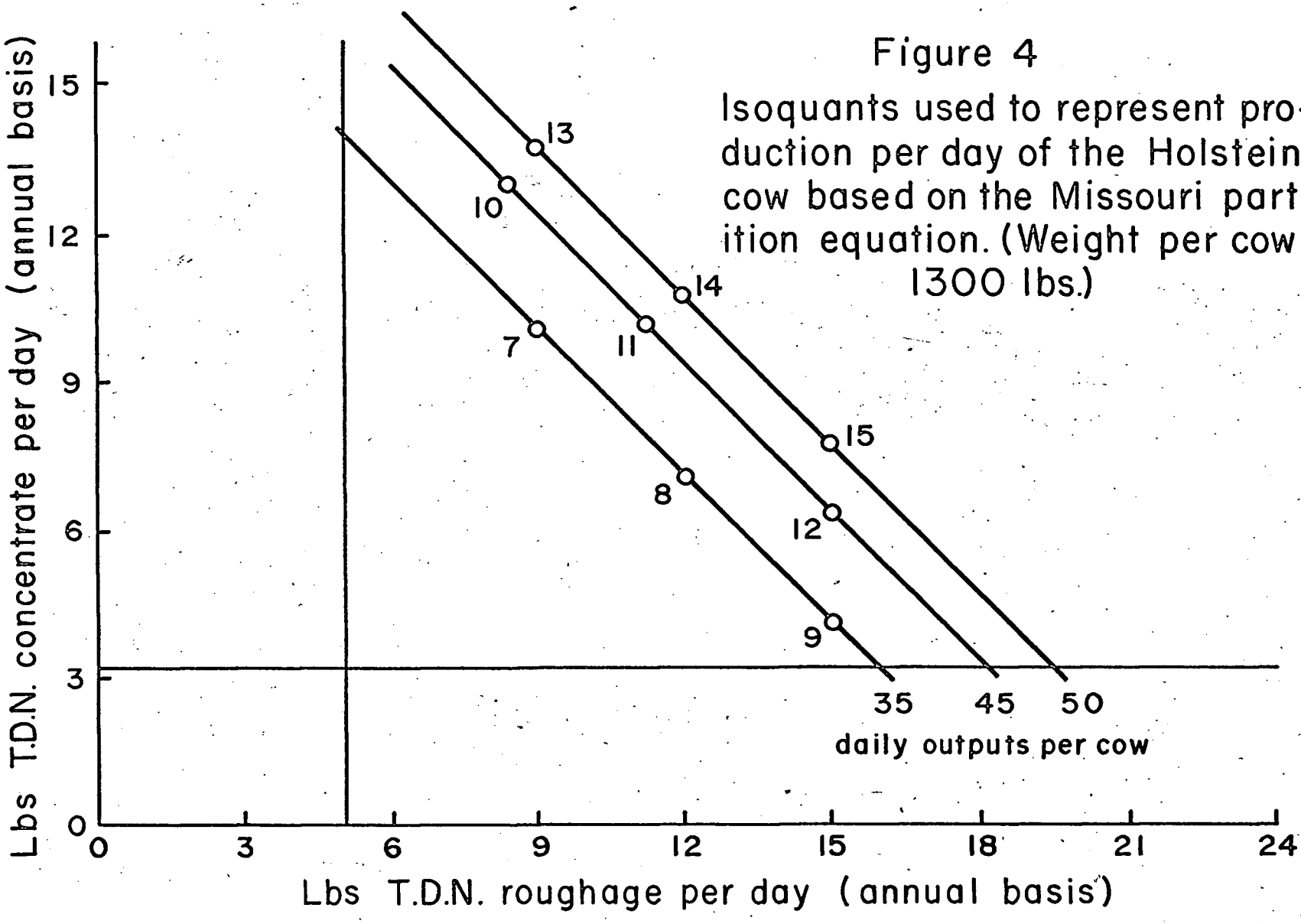

Figure 4

Isoquants used to represent production per day of the Holstein cow based on the Missouri partition equation. (Weight per cow= 1300 lbs.)

sources to determine resource requirements for labour, operating capital and building space. The main sources used were the regional studies cited previously for Vancouver Island, and the Fraser Valley and the budget studies for Washington State.

Labour Requirements

The labour requirements for the dairy activities were based on standards found in Sorboe and Woodward's study.[42] These standards represent the number of 10 hr. days required annually to care for a unit of crop or livestock. Because the Oyster River farm operates on an 8 hour day the 10 hour day standards were converted to an 8 hour day basis. It should be recognized that the use of these coefficients implies a certain level of labour efficiency. Labour efficiency will be affected by the type and quantity of capital equipment with which it is combined, and by the form (pasture, hay, silage) in which forage is fed. Coefficients were available for different methods of growing and harvesting forage but there is no reference to the degree of mechanization. Under these circumstances it was assumed that the data referred to "average" farms and that in this respect the Oyster River farm was comparable.

Annual labour requirements are a useful coefficient in some respects but the demands for labour at peak seasons of the year is often more relevant. Labour supply might be adequate for most of the year but for a particular season or seasons it could be quite limiting. Consequently it was desirable to break down the total requirements into seasonal and monthly components. For purposes of clarity, requirements for growing

42 M.M. Sorboe and E.D. Woodward, op. cit. page 49

forage were considered separately from the requirements of the chore routine. The calendar year was divided into 9 distinct periods; the first period, termed winter labour, represented the period November 1st to February 28th. The remaining periods were the months from March to October inclusive. Since the original data source did not elaborate on the distribution of labour, a distribution was made based on the best judgement of the writer. The general pattern is that the chore routine winter requirements are high and relatively constant, due mainly to the demands of feeding. As the cows get more access to pasture the labour requirements decrease and reach a fairly constant minimum during the grazing season. (the requirements for the milking operation vary little from one season to the next). Requirements for crops show just the opposite pattern with the total requirements being concentrated between April 1st and September 30th and the peak months being June, July and August. Using this reasoning as a guide the total requirements were allocated in the manner indicated in figure 5.[43] The requirements for forage harvesting and for the chore routine were then summed by periods. An adjustment factor was added or subtracted from each period sub-total representing the effect of feeding more or less forage as specified by the isoquants of figures 3 and 4. The resulting total is that presented in table XI.

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43 See appendix 15 for details of the calculation of labour coefficients.

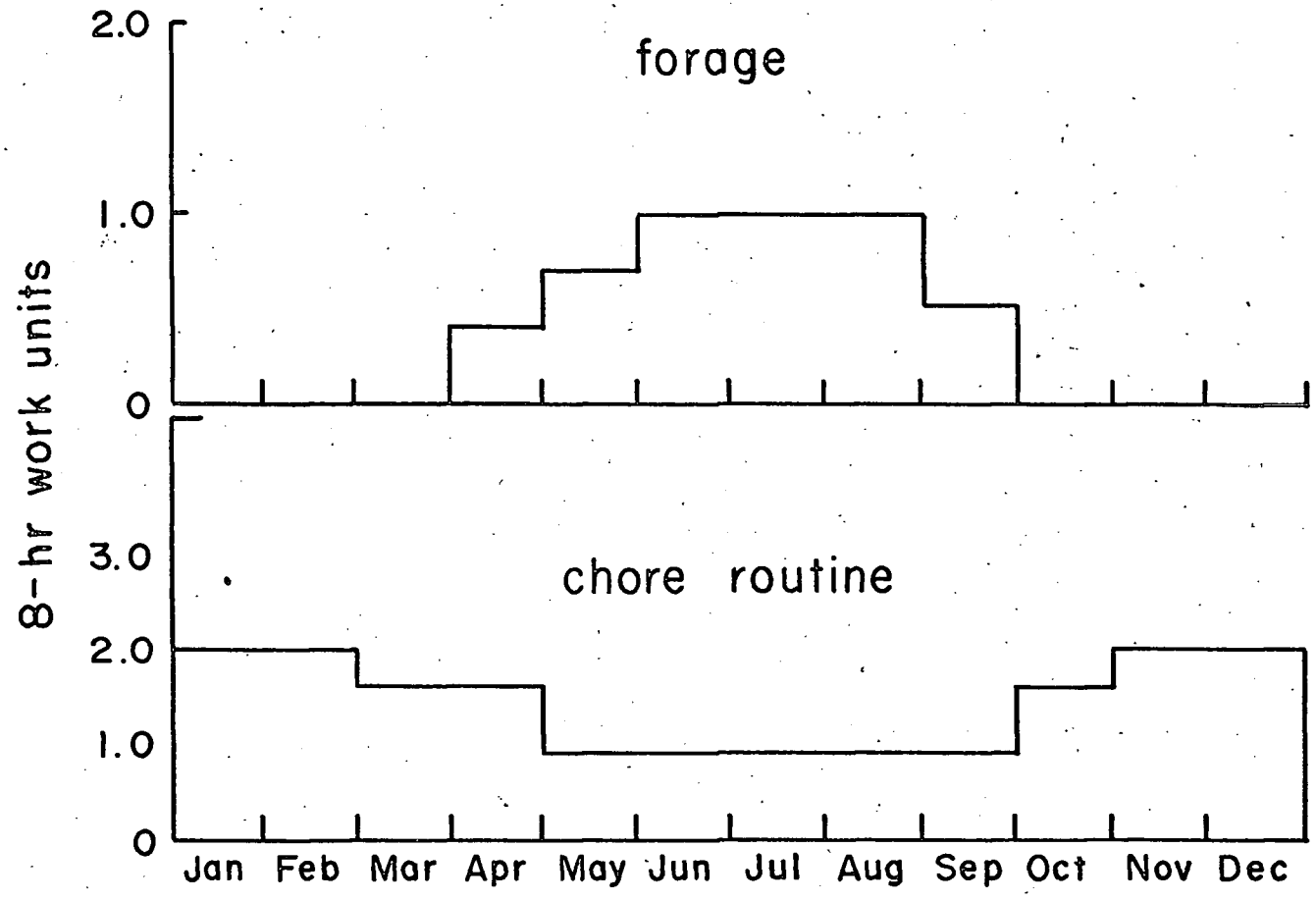

Figure 5. Dairy labour requirements of the producing unit by months for growing forage and for the chore routine.

TABLE XI

LABOUR COEFFICIENTS FOR THE DAIRY ACTIVITIES

	8 Hour Days								
ACTIVITY	WINTER	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.
A_1	7.924	1.6	2.0	1.66	1.775	1.775	1.775	1.285	1.6
A_2	8.012	1.6	2.0	1.66	1.989	1.989	1.989	1.489	1.6
A_3	8.100	1.6	2.0	1.66	2.204	2.204	2.204	1.704	1.6
A_4	8.032	1.6	2.0	1.66	2.792	2.792	2.792	2.292	1.6
A_5	8.032	1.6	2.0	1.66	2.043	2.043	2.043	1.543	1.6
A_6	8.144	1.6	2.0	1.66	2.312	2.321	2.321	1.812	1.6
A_7	7.924	1.6	2.0	1.66	1.775	1.775	1.775	1.275	1.6
A_8	8.032	1.6	2.0	1.66	2.043	2.043	2.043	1.543	1.6
A_9	8.144	1.6	2.0	1.66	2.312	2.312	2.312	1.812	1.6
A_{10}	7.852	1.6	2.0	1.66	1.601	1.601	1.601	1.101	1.6
A_{11}	8.008	1.6	2.0	1.66	1.981	1.981	1.981	1.481	1.6
A_{12}	8.144	1.6	2.0	1.66	2.312	2.312	2.312	1.812	1.6
A_{13}	7.924	1.6	2.0	1.66	1.775	1.775	1.775	1.275	1.6
A_{14}	8.032	1.6	2.0	1.66	1.968	1.968	1.968	1.468	1.6
A_{15}	8.144	1.6	2.0	1.66	2.312	2.312	2.312	1.812	1.6

Operating Capital Coefficients

Operating capital coefficients were calculated using the same regional studies of dairy farms on Vancouver Island and the Fraser Valley and the Washington State budget studies. Expenses for similar items were grouped to achieve a more reliable degree of comparability between studies. Labour costs and feed concentrate costs were calculated directly from the sections on labour and land coefficients. Labour was valued at $14.00 per 8 hour day and concentrate at $62.00 per ton.[44] Expense items such as veterinary services and supplies, dairy supplies, and livestock association fees were expressed on an animal unit basis and the amount multiplied by the number of animal units in the unit of production. Machinery expenses (variable costs only) were expressed on a per acre basis and this amount multiplied by the number of acres of land specified for each dairy activity. Artificial Insemination was included for each activity at $8.00 per cow. Milk hauling was calculated at $.200 per cwt. multiplied by the output of each activity. In all cases provision was made for the supporting young stock. The details of calculation are shown in Appendix 16 and the coefficients are presented in table XII.

Net Prices for Dairy Activities

The net prices of the dairy activities were calculated by subtracting the variable costs (they are the operating capital requirements) from the gross value of output. Gross value of output was determined by multiplying the output components of

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44 Based on average prices paid at Oyster River.

the producing unit by their respective market price. The output of the producing unit was composed of milk sales and the sale of cull cows, bred heifers, calves and yearling bulls. The calculations were as follows:

1. Milk. Milk shipped was assumed sold as 85% class I and 15% surplus. A weighted average based on these percentages was calculated using Vancouver Island milk price averages for the past two years, to arrive at a price of $5.40 per cwt.[45]
2. Bull Calves. These were considered sold within a few days of birth for $20.00 each.
3. Heifer calves were also assumed sold within a few days of birth, but at a price of $75.
4. Bred Heifers (the excess replacement stock) were assumed sold at about 20 months of age for $230 each.
5. Cull Cow. Ayrshire cull cows were valued at $138.05 and Holsteins at $163.15. Calgary prices were adjusted for the rail differential to Vancouver and for their shipment from Oyster River to Vancouver.[46]

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45 Province of British Columbia, The Milk Board Annual Report Victoria, Queens Printer, 1963, 1964.

46 Dominion Bureau of Statistics, Quarterly Bulletin of Agricultural Statistics, Ottawa, Queens Printer, 1959 - 1964

6. Bull Sales. These were animals that were retained from the better breeding stock in the belief that they would add revenues at very little additional cost. They were assumed sold at 18 months of age for $150. each.

Three activities were defined for each level of milk output specified by the isoquants of figures 3 and 4 so that five levels of output are represented by the 15 activities. The value of livestock sold was however, assumed to be the same for all activities. Remembering that the number of livestock available for sale was based on a cull rate of 20% from a herd of 82 cows the value of the unit of output was calculated as follows:

1. Bull Calves: 36/82 = .44 at $20.00
2. Heifer Calves: 13/82 = .158 at $75.00
3. Bred Heifers: 8/82 = .097 at $23.00
4. Cull Cows: 17/82 = .207 at $138.05 and $163.15
5. Yearling Bulls: 2/82 = .024 at $150.00

To this was added the appropriate level of milk output as specified in figures 3 and 4 at a price of $5.40 per cwt. Gross value of output, variable costs and net prices are summarized in table XII for each dairy activity.

Building Space Requirements.

The building space requirements are the same for all dairy activities because they were defined in terms of different requirements for land, labour and operating capital. Space requi-

rements for the dairy, beef and sheep activities are presented in Table XIII.

TABLE XII

GROSS VALUE OF OUTPUT, OPERATING CAPITAL COEFFICIENTS AND NET PRICES FOR THE DAIRY ACTIVITIES

ACTIV.	CWT. MILK (4% F.C.M.)	GROSS VALUE OF OUTPUT $	VARIABLE COSTS (OPERATING CAPITAL COEFFICIENTS) $	NET PRICE $
A_1	106.75	645.89	545.51	100.38
A_2	106.75	645.89	539.05	106.84
A_3	106.75	645.89	515.49	130.40
A_4	122.00	730.94	591.27	139.67
A_5	122.00	730.94	549.33	179.61
A_6	122.00	730.94	528.57	202.37
A_7	106.75	654.08	566.83	87.25
A_8	106.75	654.08	546.28	107.80
A_9	106.75	654.08	525.83	128.25
A_{10}	137.25	821.48	599.10	222.38
A_{11}	137.25	821.48	596.56	224.92
A_{12}	137.25	821.48	571.30	250.18
A_{13}	152.50	903.83	650.50	253.33
A_{14}	152.50	903.83	610.75	293.08
A_{15}	152.50	903.83	565.92	337.91

TABLE XIII

BUILDING SPACE REQUIREMENTS

FOR THE DAIRY, BEEF AND SHEEP ACTIVITIES

ACTIVITY	REQUIREMENTS FOR THE PRODUCING UNIT
ALL DAIRY ACTIVITIES	69.3 sq. ft.
BEEF	
COW-CALF	37.78 sq. ft.
COW-YEARLING	57.58 sq. ft.
SHEEP	18 sq. ft.

SOURCE: M.E. Ensminger, The Stockman's Handbook. Danville, Illinois, Interstate Printers and Publishers, 1959, 2nd ed.

The Beef Activities

Beef enterprises were considered for two types of activities; a cow-calf operation and a cow-yearling operation. As with the dairy operation the unit of production was one cow and her supporting young stock. The output of each unit in the case of a cow-calf operation was the sale of one calf and sale of part of a cull cow. In the case of a cow-yearling operation, it was a 1000 lb. steer and part of a cull cow. In both cases provision was made for failure to calf, or death losses.

The following management assumptions were made:

1) Calves on the average are born in the early part of March.
2) In both types of enterprise the calves are weaned in October. In the case of a cow-calf operation the calf is considered to be sold within 2 weeks of weaning (mid October) and in the case of a cow-yearling enterprise the finishing steer was considered sold as a long yearling (18 months of age) at 1000 lbs.
3) No concentrate is fed to the breeding cows.
4) Only a limited amount of winter pasture is available (10%) so that 90% of forage requirements for the winter feeding period must be met with stored forage
5) One bull is capable of servicing 45 cows
6) The culling rate for cows is 15%
7) A 90% calf crop

The technical coefficients and net prices for each beef activity are presented in Table XIV.

The land coefficients for each activity are a function of their respective forage requirements. Forage requirements were based on Morrison's standards and subsequently converted to land coefficients using the postulated yield of 2.5 tons of dry matter per acre.[47]

Labour Coefficients

Labour coefficients were calculated in the same manner as for the dairy activities. Total requirements were obtained using an average of two independent sources of data and the distribution by periods based on the best judgement of the writer.[48] Figure 6 shows the distribution by months for each activity.

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47 F.B. Morrison, Feeds and Feeding, Clinton, Iowa The Morrison Publishing Company, 1959, 22nd ed.

48 M. M. Sorboe and E.D. Woodward Dairy Farming on Vancouver Island 1961 op. cit. p. 49; J. Strohm ed. Payoff to More Farm Profits. Ford Motor Company of Canada. p. 6 Revised for Canadian conditions by C. H. Hodge.

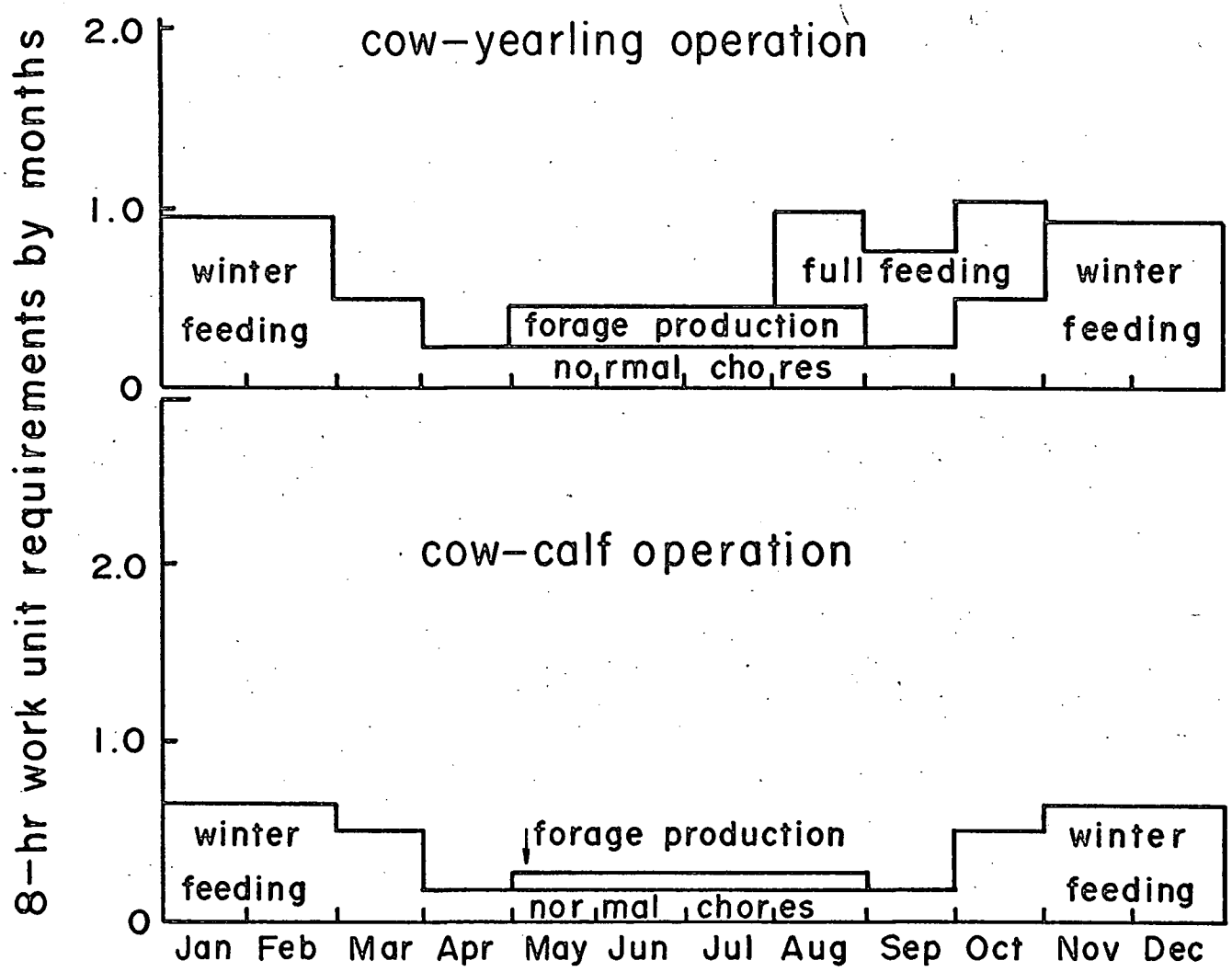

Figure 6. Beef labour requirements of the producing unit by months for growing forage and for the chore routine.

Operating Capital Requirements, Beef

In calculating operating capital requirements costs were broken down into the following categories.

1. Labour
2. Purchased feed
3. Professional services, vetinary supplies, and medicines were expressed on a per animal unit basis and multiplied by the number of animal units in the producing unit.
4. Machinery expenses, fuel oil and grease were expressed on a per acre basis and the result multiplied by the number of acres required to support the producing unit.

Labour requirements as calculated by averaging the two independent sources, were multiplied by $14.00 (the average wage rate at Oyster River) to give labour cost. Purchased feed requirements were calculated using Morrison's feeding standards and a feed concentrate cost of $62.00 per ton. Calculation of costs for professional services, medicines, and machinery and fuel expenses were based on Alberta farm business reports. Budget studies of beef operations in British Columbia and Oregon were considered but rejected because they were derived under ranch rather than farm conditions.[49] The data are presented in the following section on net prices. The operating capital coefficients for each activity are the sum of the respective variable costs.

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49 Alberta Department of Agriculture, Farm Economics Branch, Alberta Farm Business Report 1963 Edmonton.

Net Prices for Beef Activities

The variable costs of operating capital coefficients were subtracted from the gross value of output to yield the net price. Gross value of output was based on a price of $.15 per lb. for cull cows and prices of $.21 per lb. and $.20 per lb. for good calves and good steers respectively.

TABLE XIV

TECHNICAL COEFFICIENTS AND NET PRICES FOR THE BEEF ACTIVITIES.

RESOURCE	COW-CALF	COW-YEARLING
LAND		
WINTER LABOUR	2.580 days	3.640 days
MARCH LABOUR	0.500 days	0.500 days
APRIL LABOUR	0.134 days	0.200 days
MAY LABOUR	0.235 days	0.455 days
JUNE LABOUR	0.235 days	0.455 days
JULY LABOUR	0.235 days	0.455 days
AUG. LABOUR	0.235 days	1.000 days
SEPT. LABOUR	0.134 days	0.730 days
OCT. LABOUR	0.500 days	1.030 days
OP. CAPITAL ($ '00)	.973	2.044
BUILDING SPACE	37.78 sq. ft.	57.58 sq. ft.
GROSS VALUE OF OUTPUT	$105.19	$ 219.30
VARIABLE COSTS	$ 97.29	$ 204.40
NET PRICES	$ 7.90	$ 14.73

NOTE: In one of the analyses the net prices were artificially raised to determine the effect if any, on a previously optimum program. The changed net prices were $48.67 and $32.31 for the cow-calf and cow-yearling operations respectively.

The Sheep Activity

The sheep activity was included as a possibility that might more effectively utilize the acreage on the upper farm. The establishment of a sheep enterprise would be conditional upon a fairly extensive fence building or rebuilding program on the upper farm and on the construction of suitable winter shelter on the lower farm. In the sense that new construction is called for, consideration of a sheep operation departs from the linear programming principle which specifies all resources as fixed in the short run. This is not a serious objection when we consider a somewhat longer term and when depreciation and interest on investment are included as variable costs. The rationale of this approach vis a vis that used in the dairy activities (where depreciation and interest on investment were not included) is that in the latter case the investment has already been committed and is no longer part of the current management decisions. Consideration of new investment is a part of current management decisions so depreciation and interest must be included.

The calculation of the coefficients was based on the following assumption and management policies:

1. A dual purpose breed of sheep would be chosen and the unit of production would be one ewe.
2. The lambing percentage would be 125% with ewes bred to lamb in late March.
3. Ewes are bred as lambs at about 9 months of age.[50]

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50 F.B.Morrison, Feeds and Feeding op. cit. page 875. " At 5 or 6 years of age ewes bred as lambs will usually have raised an appreciably greater total weight of lambs."

4. From May 1st to Nov. 1st the ewes (and lambs until weaning and sale) would forage on the top farm. During the winter months ewes would be housed on the lower farm.

5. Student help would be utilized in caring for the sheep during the summer months.

6. Lambs would be sold in late August at a weight of 95 pounds.

7. Calculations were based on a herd size of 250 ewes, 192 of which would be of breeding age. One ram would be able to serve 30 ewes.

8. The peak labour demands would be as follows:
   -Lambing in late March.

   -Docking and castrating in April.

   -Shearing of ewes in late May.

   -Weaning and sale of lambs in late August.

9. Lamb loss was assumed to be 8%, ewe loss 5%.

As with the other livestock activities, land requirements were based on the forage requirements of the ewe (see appendix 20). Estimates of total labour requirements were allocated by periods according to known seasonal peaks.[51] The calculation of variable costs and net prices was based on a B.C. Department of Agriculture circular.[52] Table XV is a summary of the technical coefficients and the net price based on the calculations presented in appendix 20.

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51 Total labour requirements were based on estimates compiled by the Ontario Department of Agriculture, Farm Economics and Statistics branch in Sheep Business Report 1962 and Commercial Sheep Flocks 1961.

52 British Columbia Department of Agriculture, Raising Sheep in British Columbia, Victoria, 1962 (Livestock circular No.71).

TABLE XV

TECHNICAL COEFFICIENTS AND NET PRICE FOR THE SHEEP ACTIVITY

LAND		0.231 ac.	AUGUST	LABOUR	0.125
WINTER	LABOUR	0.200	SEPTEMBER	LABOUR	0.050
MARCH	LABOUR	0.200	OCTOBER	LABOUR	0.050
APRIL	LABOUR	0.145	OPERATING CAPITAL		$22.35
MAY	LABOUR	0.140	BUILDING SPACE		18 sq.ft.
JUNE	LABOUR	0.086			
JULY	LABOUR	0.086			

NET PRICE $3.28

The Potato Activity

The establishment of a potato enterprise would require an even greater capital investment than sheep. Nevertheless because potatoes appear, a priori, to offer considerable opportunity for increased net returns, they were included. As in the sheep activity new investment was accounted for by including depreciation and interest on investment as variable costs. The calculation and assumption that follow were based on cost studies in Washington State and Ontario and on the opinion of local authorities.[53] The unit of production was defined as one acre and a yield of 12 tons per acre was assumed. Since good cultural

53 Washington Agricultural Experiment Stations, Institute of Agricultural Sciences, State College of Washington, Potato Production Costs in Selected Areas of Central Washington 1954, Pullman, 1958, (Stations Circular 324);
Ontario Department of Agriculture, Farm Economics and Statistics Branch Early Potato Production Costs and Management, Toronto, 1959.

practices suggest that potatoes be grown only once every four or five years on the same land acreage was limited to a maximum of 40 acres. The requirements for new investment in the form of buildings and machinery were based on this acreage with the reservation that any program advocating potatoes at a substantially lower level would be of doubtful validity.

Labour coefficients for each of the nine periods were based on a pre-harvest total of 20 hours per acre and a harvest requirement of 48 hours per acre. Total handling requirements after harvest were estimated at 12 hours per acre. The distribution by periods was based on the best judgement of the writer and is presented in Table XVI.

Operating capital requirements were determined by summing the variable costs associated with growing one acre of potatoes (See appendix 21) and one year's depreciation and interest on investment for the new buildings and equipment that would be required.

The building space coefficient was chosen to limit the acreage in potatoes to 40 acres, though in fact 100 tons of potatoes require about 4300 cu. ft. of space plus space for handling.[54]

The net price was calculated by subtracting the variable costs (as above) from the gross value of output of one acre. Gross value of output was calculated on the basis of 12 ton yield per acre and a price of $54.00 per ton.

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54 British Columbia Department of Agriculture, Field Crops Branch, Potato Growing in British Columbia, Victoria, Queens Printer, 1952, (Bulletin No. 86 revised ed.) p. 21.

The technical coefficients and net price are summarized in Table XVI and the calculations are presented in appendix 21.

TABLE XVI

TECHNICAL COEFFICIENTS AND NET PRICE

FOR THE POTATO ACTIVITY

LAND		1 Acre	AUGUST LABOUR	.500 days
WINTER	LABOUR	1.500 days	SEPTEMBER LABOUR	6.000 days
MARCH	LABOUR	.375 days	OCTOBER LABOUR	-
APRIL	LABOUR	.500 days	OPERATING CAPITAL	$413.
MAY	LABOUR	.375 days	BUILDING SPACE	172 sq. ft.
JUNE	LABOUR	.375 days		
JULY	LABOUR	.375 days		
		NET PRICE $232.00		

The Inclusion of Purchasing and Disposal Activities and Resource Supplies

Having defined the technical coefficients and net prices for the producing activities the next steps were to add the purchasing and disposal activities and to define resource restrictions.

The supply of a resource will act as an effective constraint in maximizing the functional only to the extent that the supply cannot be augmented by a purchasing activity. In practice the supply of labour can be augmented by hiring and the supply of land "increased" by purchasing hay. Provision was made to allow purchases of labour in all nine periods and for the purchase of hay. The purchasing activities were incorporated into the problem by placing a -1.0 coefficient opposite the appropriate resource and a zero elsewhere. The price of the purchasing activity is

expressed as a negative to account for the fact that its introduction will subtract from profits. The disposal activities have a 1. in the appropriate row and column representing non-use of the resource. Table XVII shows the initial simplex matrix of coefficients(excluding the unit matrix of disposal activities).

The supply of resources was defined in terms of the effective supply rather than the apparent supply. That is, land supply was defined exclusive of the farmstead area, uncleared areas and areas already committed to a teaching or research function. The supply of labour was determined after making allowances for holidays and vacations.

Resource Supplies

55
LAND

A. Lower Farm

Field No. 1	Elite Seed Plots	
Total Area	19.25 acres	
Area Available for farm use		9.67 Acres
Field No. 2 (near sea)		6.33 Acres
Field No. 3 (McIvor Field)		22.20 Acres
Field No. 4 (Middle Field)		16.80 Acres
Field No. 5 (In front of gravel pit)		8.50 Acres
Field No. 6 (Trapesoidal field adjacent to the highway, net of log house)		5.00 Acres

Continued --

LAND[55]

A. Lower Farm (continued)

Field No. 7	(Dyke field)	25.30 Acres
Field No. 8	(Between the highway and Montfort house)	31.00 Acres
Field No. 9	(Between Montfort house and ocean)	28.80 Acres
Field No.10	(Wilkinson field, between the farmstead and the ocean)	28.30 Acres
Total available for the commercial operation		181.9 Acres
Add non-usable cleared 4.+ 9.67		13.67
Total Cleared		195.57 Acres

B. Upper Farm Area (cleared)

Field No. 1	(east of the entrance road)	36.00 Acres
Field No. 2	(west of the entrance road)	59.50 Acres
Field No. 3	(Low bench)	33.00 Acres
Field No. 4		8.00 Acres
		136.50 Acres.

Upper farm cleared acreage was "converted" to the equivalent in terms of lower farm acreage. In this way it was only necessary to define one type of land while still accounting for the differences in productivity. Using yields of 2.50 tons and 0.75 tons of dry matter on the lower and upper farm areas respectively, one acre of lower farm land will substitute for

$$\frac{2.5}{0.75} = 3.34 \text{ acres of upper farm land.}$$

The total usable acreage using this transformation is

55 Acreages were calculated using a partial survey complemented by the use of aerial photographs and a planimeter.

182.00 acres plus $\frac{136.5}{3.34}$ = 223.00 acres.

BUILDINGS

A. Dairy

Loafing barn (1964)	44' x 167'	106 stalls
Covered Holding Area	124' x 20'	
Loafing and Feeding	167' x 77'	Equipped with central feeding
Total Dairy Area	7348 sq. ft.	

B. Beef Barn. Pole Frame Construction.

Overall size	180' x 60', 324 lineal feet of feeding space accessible from 4 pens 18½' x 81' for a total livestock area of 5670 sq. ft.
Total Area	5670 sq. ft.

It was assumed that dairy and beef building space were interchangeable so that total building space for the dairy and beef enterprises was 13018 sq. ft. Feed storage space was not considered critical.[56]

Labour Supply

The total supply is composed of the regular farm staff plus student labour for the summer. An allowance was made for the fact that most of the regular staff take their vacation during the summer months. The time available from the manager for the commercial operations was estimated at half that of a normal worker. The remainder of his time was taken up with administration and the non-commercial activities.

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56 The capacity of the 6 silos was estimated at 684 tons assuming a density of 40 lbs. per cubic foot.

The regular staff --

Manager	0.5 man equivalents
Herdsmen (3)	3.0 man equivalents
Mechanic (1)	1.0 man equivalents
Other help (2)	2.0 man equivalents

Student help is available from 2 students for the summer months, May, June, July and August. The regular staff will provide an average of 20.5 work days per month (allowing for vacations) and the students an average of 24 work days per month.

A. The labour supply for the months of May, June, July and August.

Regular help	6.5(20.5)	=	133.75 work days per month
Student help	2 (24)	=	48.00
Total per month			181.75

(This was rounded to 182 days.)

B. Labour Supply for March, April, Sept. and Oct.

Regular help	6.5(24)	156.0 work days per month

C. Labour Supply for the winter period Nov. 1st through to February 28th.

4 month (156 days per month)	624.00

Operating Capital Supply

The supply of operating capital in any one year is more indeterminate than the supply of other resources since it largely rests on approval of budget estimates by the University authorities. For this reason the availability of operating capital was not taken to be a restricting resource in the linear program-

ming analysis. Therefore a level of $75,000.00 was assumed which satisfied the above conditions and in addition, allowed an assessment of the amount of operating capital required in the optimum programs.

The initial simplex matrix of Table XVII provides a summary of the resource coefficients for each activity. Dairy activities are represented by numbers 1 to 15, with the first six representing the Ayrshire breed and the remaining nine the Holstein breed. Activities 16 and 17 are the beef cow-calf and cow-yearling operations respectively. Number 18 is the sheep activity. Number 19 was left blank and could have been used to define another activity without changing the dimensions of the matrix. The potato activity is represented by number 20. Activities 21 to 30 represent purchasing activities for hay (number 21) and labour (numbers 22 to 30). Hay purchasing had the effect of adding to the supply of land since only forage was assumed grown on the farm. The labour purchasing activities, as presented, added to the supply of labour in each of the nine periods but for some of the analyses labour purchasing was restricted to the months of May, June, July, August and September. For these analyses the -1. coefficients in the rows representing the labour periods of Winter, March, April and October were replaced by zeros. Disposal or non-use activities have been omitted from Table XVII but they would be represented by a set of ones running on the diagonal from row 1 column 31 to row 14 column 44.

TABLE XVII

THE INITIAL SIMPLEX MATRIX OF REAL ACTIVITIES

RESOURCE		LEVEL	1	2	3	4	5	6	7	8	9	10
LAND		223.	1.34	1.65	1.96	1.34	1.73	2.12	1.34	1.73	2.12	1.08
WINTER	LABOUR	624.	7.92	8.01	8.10	8.03	8.03	8.14	7.92	8.03	8.14	7.85
MARCH	LABOUR	156.	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
APRIL	LABOUR	156.	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
MAY	LABOUR	182.	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
JUNE	LABOUR	182.	1.77	1.99	2.20	2.79	2.04	2.31	1.77	2.04	2.31	1.60
JULY	LABOUR	182.	1.77	1.99	2.20	2.79	2.04	2.32	1.77	2.04	2.31	1.60
AUGUST	LABOUR	182.	1.77	1.99	2.20	2.79	2.04	2.32	1.77	2.04	2.31	1.60
SEPT.	LABOUR	156.	1.28	1.49	1.70	2.29	1.54	1.81	1.27	1.54	1.81	1.10
OCT.	LABOUR	156.	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
OPERATING CAPITAL	($-00)	750.	5.45	5.39	5.15	5.91	5.49	5.28	5.67	5.46	5.26	5.99
BLDG. SPACE DAIRY OR BEEF		13018.	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3
BLDG. SPACE POTATOES		6880.	0	0	0	0	0	0	0	0	0	0
BLDG. SPACE SHEEP		5400.	0	0	0	0	0	0	0	0	0	0

Continued -

TABLE XVII (Continued)

THE INITIAL SIMPLEX MATRIX OF REAL ACTIVITIES

RESOURCE	LEVEL	11	12	13	14	15	16	17	18	19	20
LAND	223.	1.64	2.12	1.34	1.73	2.12	1.70	-2.20	0.231	0	1.0
WINTER LABOUR		8.01	8.14	7.92	8.03	8.14	2.58	3.64	0.20	0	1.25
MARCH LABOUR		1.60	1.60	1.60	1.60	1.60	0.50	0.50	0.20	0	0.37
APRIL LABOUR		2.00	2.00	2.00	2.00	2.00	0.13	0.20	0.14	0	0.50
MAY LABOUR		1.66	1.66	1.66	1.66	1.66	0.23	0.45	0.14	0	0.37
JUNE LABOUR		1.98	2.31	1.77	1.97	2.31	0.23	0.45	0.09	0	0.37
JULY LABOUR		1.98	2.31	1.77	1.97	2.31	0.23	0.45	0.09	0	0.37
AUGUST LABOUR		1.98	2.31	1.77	1.97	2.31	0.23	1.00	0.12	0	0.50
SEPT. LABOUR		1.48	1.81	1.27	1.47	1.81	0.13	0.73	0.05	0	6.00
OCT. LABOUR		1.60	1.60	1.60	1.60	1.60	0.50	1.03	0.05	0	0
OPERATING CAPITAL		5.96	5.71	6.50	6.11	5.66	0.97	2.04	.223	0	4.15
BLDG. SPACE DAIRY OR BEEF		69.3	69.3	69.3	69.3	69.3	37.8	57.6	0	0	0
BLDG. SPACE POTATOES		0	0	0	0	0	0	0	0	0	172.
BLDG. SPACE SHEEP		0	0	0	0	0	0	0	0	0	0

Continued -

TABLE XVII (Continued)

THE INITIAL SIMPLEX MATRIX OF REAL ACTIVITIES

RESOURCE		LEVEL	21	22	23	24	25	26	27	28	29	30
LAND			-1.0	0	0	0	0	0	0	0	0	0
WINTER	LABOUR		0	-1.	0	0	0	0	0	0	0	0
MARCH	LABOUR		0	0	-1.	0	0	0	0	0	0	0
APRIL	LABOUR		0	0	0	-1.	0	0	0	0	0	0
MAY	LABOUR		0	0	0	0	-1.	0	0	0	0	0
JUNE	LABOUR		0	0	0	0	0	-1.	0	0	0	0
JULY	LABOUR		0	0	0	0	0	0	-1.	0	0	0
AUGUST	LABOUR		0	0	0	0	0	0	0	-1.	0	0
SEPT.	LABOUR		0	0	0	0	0	0	0	0	-1.	0
OCT.	LABOUR		0	0	0	0	0	0	0	0	0	-1.
OPERATING CAPITAL			117.5	10.	10.	10.	10.	10.	10.	10.	10.	10.
BLDG. SPACE DAIRY OR BEEF			0	0	0	0	0	0	0	0	0	0
BLDG. SPACE POTATOES			0	0	0	0	0	0	0	0	0	0
BLDG. SPACE SHEEP			0	0	0	0	0	0	0	0	0	0

Setting Up the Analysis

The next step was to determine the appropriate form of the analysis. The availability of an electronic computer greatly facilitated the task of solving the linear programming problem so it would have been possible to analyze a large number of different situations. It was reasoned however that a more efficient approach was to limit the number of analyses to those that promised to be the most meaningful.[57] As a result four basic analyses were undertaken postulating two sets of circumstances. In the first, unrestricted labour purchasing was compared with labour purchasing restricted to the months of May, June, July, August and September. This classification was chosen to examine the effect of departing from the present system where additional labour purchasing is largely restricted to the summer months. Also, preliminary solutions suggested that labour restrictions were among the most critical in arriving at an optimum program thus fortifying the importance of an examination of the two situations.

The second set of analyses compared a situation that preincluded 30 Ayrshire cows with one that considered all activities without restrictions. The reason for this classification was to take cognisance of the experimental objective involving the Ayrshire herd.[58] Thus consideration of these situations under the

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57 The program for the linear programming analysis was obtained from the U.B.C. computing center.

58 The Ayrshire herd at Oyster River is an integral part of a long term cross breeding experiment.

labour classification mentioned above resulted in four analyses. A fifth analysis was undertaken after examining the results of the first four. Neither the beef nor the sheep activities were profitable enough to be included in any of the first four analyses so the effect of raising the price of these activities with labour unrestrictive was examined.[59]

The analyses may be summarized as follows:

Analysis I ; consideration of all activities, labour purchase permitted in all periods

Analysis II ; consideration of all activities, labour purchase limited to May, June, July, August and September

Analysis III ; consideration of all activities, 30 Ayrshire cows pre-included, labour purchase permitted in all periods

Analysis IV ; consideration of all activities, 30 Ayrshire cows pre-included, labour purchase restricted to the months of May, June, July, August and September

Analysis V ; this was the same as analysis III except that the net prices of the beef and sheep activities were raised.

In each of the analyses a test was conducted of the price stability of activities in the optimum plan. It was useful to know the price range for which the plans remained optimum since activities that showed substantial stability about their net price could be recommended with more confidence. As it happened only the minimum price had any practical significance for potatoes. They were introduced to the maximum at a net price of $232. per

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59 The higher net price corresponded to the highest market prices for calves, steers and lambs over the past five years.

acre and a higher price would not bring more units into the plan.[60]

The Results of the Analyses

Analysis I

A summary of analysis I is presented in Table XVIII. The optimum plan recommends 86 cows producing 50 lbs. of 4% F.C.M. per day, 40 acres of potatoes and labour purchasing for the winter period, April, June, July, August and September. March labour, May labour and October labour are in excess supply, as is operating capital and building space for dairy (or beef) and sheep.

Ten iterations were required before the optimum plan was realized with the functional increasing from $25,890.94 in the first to $33,398.81 in the last. The order in which activities enter the program depends on the units in which they are defined. Whether an activity will remain in the plan depends on its marginal rate of substitution with other activities in terms of the scarcest resource(s). As the iterations proceed, the marginal rates of substitution change as other resources become more limiting.

In the first iteration of Table XVIII the total supply of winter labour was exhausted in producing 76.3 units of dairy 15.[61] In the second iteration the remaining supply of September labour was "converted" to a less than maximum amount of potato activity.

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60 As mentioned earlier potatoes were limited to a maximum of 40 acres to be consistent with good rotational practices.

61 The number of cows was determined by dividing the value of the functional by the net price of activity 15.

At this point it became profitable to hire winter labour so that it was no longer restrictive. April labour then became the most restrictive. In turn it became profitable to hire labour for April, August and June as each became restrictive. No change occurred in the value of the functional between iteration 5 and iteration 6 but the functional was increased in iteration 7 by removing potatoes from the plan and purchasing July labour. The activity, dairy 15, originally came in at a level of 76.3 cows so the effect of the labour purchasing activities was to permit an increase in the number of cows to 86.2. Potatoes re-entered the plan in the 9th iteration using up all of the remaining land. The final restriction for potatoes was potato building space which proved more limiting than March labour so 3 days of March labour were returned to disposal.

The Stability of the Optimum Program With Respect to Price Changes for Dairy 15 and Potatoes.

Remembering that an optimum plan has been achieved when the net marginal revenues[62] of real activities not in the plan are greater than or equal to zero ($Z_j - C_j \geq 0$), any change in price that will cause a negative $Z_j - C_j$ will result in a plan becoming sub-optimal.

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62 The $Z_j - C_j$ values represent the net marginal revenues of producing a particular activity. The fact that a negative $Z_j - C_j$ will increase profit if the activity is introduced is due to the formulation of the criterion equation, e.g. if the criterion equation was $C_j - Z_j$ a positive value would add to profit.

TABLE XVIII

ANALYSIS I

CONSIDERATION OF ALL ACTIVITIES
LABOUR PURCHASE PERMITTED IN ALL PERIODS

ACTIVITY OR RESOURCE IN	ACTIVITY OR RESOURCE OUT	RETURN TO FIXED FACTORS $	LEVEL OF ACTIVITY IN THE OPTIMUM PLAN
DAIRY #15	WINTER LABOUR	25,890.94	86 cows
POTATOES	SEPT. LABOUR	26,431.27	40 acres
WINTER LAB.PUR.	APRIL LABOUR	26,688.74	128.3 days
APRIL LAB.PUR.	AUGUST LABOUR	26,806.99	31.5 days
AUG.LAB.PURCH.	JUNE LABOUR	26,827.27	32.4 days
JUNE LAB. PUR.	JULY LABOUR	26,827.27	32.4 days
JULY LAB. PUR.	POTATOES	27,646.95	37.4 days
SEPT.LAB.PURC.	MARCH LABOUR	29,346.52	240.3 days
POTATOES	LAND	32,817.41	40.0 Acres
MARCH LAB.DISP.	POTATO BLDG.	33,398.81	3.0
RESOURCES IN DISPOSAL			
MAY LABOUR			3.8 days
OCTOBER LABOUR			8.0 days
OPERATING CAPITAL			$5,773.
DAIRY & BEEF BLDG.			7,042 sq. ft.
SHEEP BLDG.			5,400 sq. ft.

NOTE: Number of cows has been rounded to the nearest whole number.

THE STABILITY OF THE OPTIMUM PLAN WITH RESPECT TO PRICE

ACTIVITY	NET PRICE IN THE PLAN	MAX. STABILITY PRICE	MINIMUM STABILITY PRICE
DAIRY #15	$ 337.91	$ 438.24	$334.85
POTATOES	232.00	-	$158.76

NOTE: The return to fixed factors of production is synonymous with the value of the functional.

$Z_j - C_j$ has been defined as $\sum_i C_i r_{ij} - C_j$

Alternatively $Z_j - C_j = C_d r_{dj} + \sum_i C_i r_{ij} - C_j$ where the summation over i includes all rows except the dairy row and C_d and r_d refer to the dairy activity.[63]

Consider now a change in the price of the dairy activity ΔC_d. The new $Z_j - C_j$ designated $Z_j - C_j'$ may be written

$Z_j - C_j' = \Delta C_d r_{dj} + (Z_j - C_j)$ where the summation over i includes all rows other than the dairy row. Now for any change in price ΔC_d such that $Z_j - C_j' \geq 0$ the plan of Table XVIII is optimum. For $Z_j - C_j' < 0$ the plan becomes sub-optimal, i.e. if

$\Delta C_d \cdot r_{dj} + (Z_j - C_j) < 0$ (1) then the plan becomes sub-optimum.

Rearranging (1) we get the condition that $\Delta C_d > \frac{Z_j - C_j}{-r_{dj}}$ (2)

If we are considering an increase in price then ΔC_d is positive. $Z_j - C_j$ must also be positive or the plan in Table XVIII would not be optimum, therefore the coefficient r_{dj} must be negative. Similar reasoning applies in determining the price below which the plan in Table XVIII becomes sub-optimum. That is, a price decline $\Delta C_d > \frac{Z_j - C_j}{r_{dj}}$ will define a new optimum program where r_{dj} takes on a positive value.

The computer output contained the information of Table XVIII, the $Z_j - C_j$ values (termed "shadow costs") and the final matrix of the simplex solution. Reference to the columns headed "variable

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63 The r_{dj} coefficients referred to are those of the final matrix which because of its length has been omitted.

in" and "variable out" identified the dairy row. The Z_j-C_j values were divided by the negative r_{dj} coefficients in the dairy row to find the smallest price rise above which the plan becomes sub-optimal. Division by the positive r_{dj} coefficients defined the lower limit. The maximum increase in price was calculated as $\frac{47.288}{-0.4713}$ or -100.335.[64] Adding this to the net price of $337.91 we get an upper limit of stability of $438.24. At prices above this the plan in Table XVIII becomes sub-optimum. Performing the same calculations with the positive r_{dj} the maximum decrease in price consistent with stability was $3.06 . Subtracting this from $337.91 yields a lower limit of stability of $334.85.

In the case of potatoes it was only necessary to determine the lower limit of stability. The smallest positive $\frac{Z_j-C_j}{r_{dj}}$ was calculated to be $73.41 . The lower range of stability was $232. - $73.41 or $158.76 .

It is important to remember in discussing price stability that we are dealing with only one activity at a time and all other prices and coefficients remain constant. The range of stability for the dairy activity is valid only when the price of the potato activity is held constant, at its original level. Similarly the lower range for potatoes is valid only when the price of the dairy activity is held constant.

This need not be a serious limitation when there are only two producing activities in the optimum plan. Furthermore the

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64 It is the absolute value of the change that is considered.

fact that the potato net price ($232.) is well within the lower limit of stability (158.76) lends substantial support to the recommendation of a potato enterprise. In the case of the dairy activity (number 15) the net price is biased toward the lower limit so that a price decline greater than $3.06 will cause the plan to become sub-optimum. Again, this is not a serious limitation because the next highest price dairy activity (number 14) will enter.[65]

Analysis II.

The second analysis is summarized in Table XIX. The functional was maximized at $30,967.70 or about $2400. less than in the first analysis where labour purchasing was not restricted. The most restricting resources were labour for August, September and the Winter period and potato building space. Land, though restrictive in Analysis I, was in excess supply. Activity 15 (dairy) was the first to enter the program, completely replacing winter labour. In the second iteration potatoes entered at a lower than maximum level and exhausted the remaining September labour. September labour purchasing then became profitable and September labour ceased to be a restriction. August labour became restrictive and was supplemented by its purchasing activity. In the final iteration the supply of potato building space was exhausted. The number of cows entering the first iteration exceeded that in the final iteration as potatoes were gradually introduced to the maximum permitted by building space. The range of price stab-

65 This was confirmed by calculating new $Z_j - C_j$ values for activities 14, 16, 17 and 18 using a price for activity 15 just below the lower limit of stability. Only number 14 had a negative $Z_j - C_j$.

ility was calculated as in Analysis I. The plan will remain optimum for dairy prices of $303.57 to $1122.58 and for potato net prices greater than or equal to $110.24 per acre.

Analysis III.

The third analysis is summarized in Table XX and contains a built in restriction of thirty Ayrshire cows with all other activities remaining as before.[66] Labour purchases were permitted in all periods. It is essentially the same as Analysis I except that the resource supplies have been reduced by the requirements for the 30 Ayrshire cows. The labour purchasing activities differ only fractionally and there are differences in the quantities of surplus resources. The activities enter the plan in the same order as in I and resources are exhausted in the same order. The final matrix and the Z_j-C_j values are identical so the same range of stability applies in both cases. That is, the plan will remain optimum for Dairy prices between $334.85 and $438.24 and for potato net prices greater than or equal to $158.76 per acre. The return to fixed factors must be increased by the net price of the 30 Ayrshires resulting in a total return of $29,324.51. This was $4,074.30 less than in the first analysis due to the lower net price of the Ayrshire activity.

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66 The Ayrshire cow was represented by activity number 6.

TABLE XIX
ANALYSIS II

CONSIDERATION OF ALL ACTIVITIES
LABOUR PURCHASES LIMITED TO MAY, JUNE
JULY, AUGUST AND SEPTEMBER

ACTIVITY OR RESOURCE IN	ACTIVITY OR RESOURCE OUT	RETURN TO FIXED FACTORS	LEVEL OF ACTIVITY IN THE OPTIMUM PLAN	
		$		
DAIRY #15	WINTER LABOUR	25,890.94	70	cows
POTATOES	SEPT. LABOUR	26,431.27	40	acres
SEPT.LAB.PURCH.	AUG. LABOUR	30,172.26	211.7	days
AUG. LAB.PURCH.	POTATO BUILD.	30,969.70	0.9	days
RESOURCES IN DISPOSAL				
LAND			33.4	acres
MARCH LABOUR			28.2	days
APRIL LABOUR			.04	days
MAY LABOUR			50.0	days
JUNE LABOUR			4.0	days
JULY LABOUR			4.0	days
OCT. LABOUR			33.2	days
OPERATING CAPITAL			$17,586.	
DAIRY & BEEF BLDG.			8,133.6	sq.ft.
SHEEP BLDG.			5,400.	sq.ft.

THE STABILITY OF THE OPTIMUM PLAN WITH RESPECT TO PRICE.

ACTIVITY	NET PRICE OF ACTIVITY	MIN. STABILITY PRICE	MAX. STABILITY PRICE
DAIRY #15	$ 337.91	$ 303.57	$1,122.58
POTATOES	$ 232.	$110.24	-

TABLE XX

ANALYSIS III

CONSIDERATION OF ALL ACTIVITIES, 30 AYRSHIRE COWS PRE-INCLUDED, LABOUR PURCHASE PERMITTED IN ALL PERIODS

ACTIVITY OR RESOURCE IN	ACTIVITY OR RESOURCE OUT	RETURN TO FIXED FACTORS $	LEVEL OF ACTIVITY IN THE OPTIMUM PLAN
DAIRY #15	WINTER LABOUR	15,753.64	56 cows
POTATOES	SEPT. LABOUR	16,293.97	40 acres
WINTER LAB.PURCH.	APRIL LABOUR	16,551.44	128.3 days
APRIL LAB.PURCH.	AUGUST LABOUR	16,648.29	31.4 days
AUG.LAB.PURCH.	JUNE LABOUR	16,668.88	32.6 days
JUNE LAB.PURCH.	JULY LABOUR	16,668.88	32.6 days
JULY LAB.PURCH.	POTATOES	17,501.55	37.0 days
SEPT.LAB.PURCH.	MARCH LABOUR	19,201.12	240.2 days
POTATOES	LAND	22,672.01	
MARCH LAB.DISP.	POTATO BUILDINGS	23,253.41	3.02 days

RESOURCES IN DISPOSAL

MAY LABOUR	23.8 days
OCTOBER LABOUR	8.02 days
OPERATING CAPITAL	$ 6,885.45
DAIRY & BEEF BLDG.	7,041.6 sq.ft.
SHEEP BUILDING	5,400.0 sq.ft.

THE STABILITY OF THE OPTIMUM PLAN WITH RESPECT TO PRICE.

ACTIVITY	NET PRICE OF ACTIVITY	MIN.STABILITY PRICE	MAX.STABILITY PRICE
DAIRY #15	$ 337.91	$ 334.85	$ 438.24
POTATOES	$ 232.00	$ 158.76	-

Analysis IV

As with Analysis I and III, Analysis II and IV parallel each other (see Table XXI). The order of entry of activities and exhaustion of resources is identical. Differences occur in the quantities of purchasing activities and in the quantities of surplus resources. The final matrix of coefficients and the $Z_j - C_j$ values are identical. The return to fixed factors is lower than in Analysis III due to the added labour restrictions. The total return to fixed factors is obtained by adding the product of the 30 Ayrshires and their net prices to the value of the functional in the program to arrive at a total of $26,900.80. Therefore the inclusion of the Ayrshire herd under conditions of restricted labour purchasing resulted in a reduction of the functional of over $2,400.00 from the level attained in Analysis III. The combined effect of restricted labour purchasing and the inclusion of 30 Ayrshire cows resulted in a reduction of the functional of about $6,500.

Analysis V

The purpose of this analysis was to test the effect of a moderate increase in price of the sheep and beef activities. It is impossible to apply the tests of stability used previously for an activity not already in the program so an alternate method was sought. Increasing the price arbitrarily, to see if an activity can be brought into the program is a trial and error method, but it has the advantage of simplicity and in this particular case it established a point. The point is that even

using the highest market prices over the past six years neither the beef nor the sheep activities were profitable enough to displace the dairy activity 15 or the potato activity.

The most significant conclusion to be drawn from these analyses is the overwhelming dominance of the high producing dairy activity and the potato activity. In each case potatoes have been called for up to the maximum allowed by the building restriction and activity 15 is recommended to the maximum, consistent with the restrictions of the respective analyses. The generally wide range of price stability reinforces the recommendations. In the case of the dairy activity in Analyses I and III a relatively small drop in price ($\geq$\$3.06) will cause the plan to become sub-optimal but this is not a serious limitation in that activity 14 is likely to replace some or all of activity 15.

It is significant that land was limiting only when labour purchases were permitted in all periods but in no case was it profitable to purchase more "land".[67] The cost of purchasing an added 2.8 tons of hay was \$117.50 whereas the net marginal revenue of land was \$70.21. Only at prices below this would hay purchasing have been profitable. In Analyses I and III where labour purchasing was permitted for all periods, land became restrictive but in no case was it profitable to "add" to the supply of land by purchasing hay.

In the opinion of the writer the most relevant analysis for the Oyster River farm are numbers III and IV. In both analyses an Ayrshire herd of 30 cows is forced into the program to be con-

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67 It has been pointed out earlier that the hay purchasing activity had the effect of adding to the supply of land since only forage was assumed to be grown on the farm.

TABLE XXI

ANALYSIS IV

CONSIDERATION OF ALL ACTIVITIES, 30 AYRSHIRE COWS PRE-INCLUDED LABOUR PURCHASES RESTRICTED TO MAY, JUNE, JULY, AUGUST AND SEPTEMBER

Activity or Resource IN	Activity or Resource OUT	Return To Fixed Factors $	Level of Activity In the Optimum Plan
Dairy #15	Winter Labour	15,753.64	40 Cows
Potatoes	Sept. Labour	16,293.97	40 Acres
Sept.Lab. Purch.	Aug. Labour	19,806.30	211.7 Days
Aug.Lab.Purch.	Potato Build.	20,829.70	1.2 Days
RESOURCES IN DISPOSAL			
Land			33.4 Acres
March Labour			28.2 Days
April Labour			.04 Days
May Labour			50.0 Days
June Labour			3.7 Days
July Labour			3.7 Days
Oct. Labour			33.2 Days
Operating Capital			$ 18,704.35
Dairy & Beef Bldg.			8,133.6 Sq.Ft.
Sheep Bldg.			5,400.0 Sq.Ft.

The stability of the optimum plan with respect to price.

ACTIVITY	NET PRICE OF ACTIVITY	MIN. STABILITY PRICE	MAX. STABILITY PRICE
Dairy #15	$ 337.91	$ 303.57	1122.58
Potatoes	$ 232.00	$ 110.24	-

TABLE XXII

ANALYSIS V

CONSIDERATION OF ALL ACTIVITIES, 30 AYRSHIRE COWS PRE-INCLUDED, LABOUR PURCHASE PERMITTED IN ALL PERIODS AND THE PRICE OF BEEF AND SHEEP ACTIVITIES RAISED

Activity or Resource In	Activity or Resource Out	Return to Fixed Factors $	Level of Activity in the Optimum Plan
Dairy #15	Winter Labour	15,753.64	56 Cows
Potatoes	Sept. Labour	16,293.97	40 Acres
Winter Lab.Purch.	April Labour	16,551.44	128.3 Days
April Lab.Purch.	August Labour	16,648.29	31.4 Days
Aug. Lab.Purch.	June Labour	16,668.88	32.6 Days
June Lab. Purch	July Labour	16,668.88	32.6 Days
July Lab. Purch	Potatoes	17,501.55	37.0 Days
Sept.Lab.Purch.	March Labour	19,201.12	240.2 Days
Potatoes	Land	22,672.01	
March Lab.Disp.	Potato Buildings	23,253.41	3.02 Days

Resources in Disposal May Labour	23.8 Days
October Labour	8.02 Days
Operating Capital	$ 6,885.45
Dairy & Beef Building	7,041.6 Sq.Ft.
Sheep Building	5,400.0 Sq.Ft.

The Stability of the optimum plan with respect to price.

ACTIVITY	NET PRICE OF ACTIVITY	MIN.STABILITY PRICE	MAX.STABILITY PRICE
Dairy #15	$ 337.91	$ 334.85	$ 438.24
Potatoes	$ 232.00	$ 158.76	-

-sistent with one of the farm's experimental objectives. A reduction in net returns was incurred but net income was still satisfactory, providing a rate of return on investment of 5.85% and 5.14% respectively.[68] Potatoes in both cases were recommended to the maximum consistent with good rotational practices. The number of cows recommended was 86 where labour was unrestrictive and 70 cows where it was restrictive.

It is apparent from examining these recommendations that the labour coefficients have been overestimated since the present Oyster River herd of nearly 100 cows is maintained by the same labour supply postulated in Analysis IV. It is unlikely that such an error would result in an incorrect choice of activities since the same method of calculation was used for each activity. The principal effect will be an understatement of the farm's capacity, hence an understatement of net returns. The selection of a single analysis as being most relevant for the Oyster River farm will depend on the practical problems of implementing the two analyses.

The Practical Problems of Implementing the Optimum Plan.

The practical problems of effecting the plan are (1) Raising the average production per cow to the levels specified in activity 6 (Ayrshires) and activity 15 (Holsteins). This involves raising the average of the Ayrshire cows from the present 10,784 lbs. of milk (and 416 lbs. fat) to 12,200 lbs. of milk and 488 lbs. of fat. The Holstein average must be raised from 13,406 lbs. of milk with 610 lbs. of fat to 15,250 lbs.

68 The rate of return on investment was calculated by subtracting depreciation from the value of the functional and expressing the remainder as a percentage of average net worth.

of milk with 620 lbs. of fat. (2) The problem of hiring the additional labour called for by Analysis III and (3) The problem of establishing a potato enterprise and a marketing quota. It should also be recognized that the implementation of the recommendations of either analysis could take five or more years.

Increasing the milk production per cow involves the selection of superior animals and close attention to feeding practices. The animals must consume sufficient T.D.N.'s to maintain body weight and to produce the specified quantities of milk. The form in which it should be fed depends on the nature of the milk isoquants. With linear or near linear isoquants and a price of a lb. of T.D.N. in concentrate form greater than a lb. of T.D.N. in forage form, the latter should be fed to the maximum consistent with consuming sufficient T.D.N.'s.[69] For example, with a cow producing at 15,250 lbs. of 4% F.C.M. it is impossible to maintain this level of production on forage alone because of it's limited stomach capacity. In order to maintain production a more concentrated feed must be fed.

Having decided that Analysis III and IV were the more relevant, the choice between the two depends on the feasibility of hiring the additional labour specified in Analysis III. If it is feasible to hire this labour, then III is superior because of its higher net return. Hiring one more man on an annual basis would more than satisfy the winter purchasing requirements and very nearly the requirements in April, June, July and August. Additional labour for potato harvesting in September would still be required. Surplus labour would result for the months of

69 In the case where the price of a lb. of T.D.N. in concentrate form is less than the price of a lb. in forage form, concentrate should be substituted for forage.

March, May, and October. The ideal situation would be to hire the added labour only in the months in which it is required. However when skilled labour is required, year round employment seems the only practical solution. The problem of hiring the added labour specified in Analysis III may be more imaginary than real, remembering that the labour coefficients have been overstated. The fact is that more cows are presently being cared for than are called for in Analysis III so the recommendations of this analysis with respect to labour requirements and the number of cows can be confidently accepted.

The problem of establishing a substantial potato marketing quota in a short time is more difficult. Quotas are used to regulate the flow of products to the available markets in proportion to each grower's past five-year performance. An initial quota of 4 tons of say, late potatoes would revolve not less than twice during the first year and perhaps as many as twelve times. The quota in the next year would be one fifth of the quantity marketed in the first year and this in turn would revolve a number of times. If one assumes that a quota would revolve an average of 7 times per year over a ten year period it would take nearly 10 years to build a quota large enough to market the produce of 40 acres (about 500 tons). However the writer was assured that although Vancouver Island was nearly self sufficient in potato production, few marketing problems would arise if adequate storage facilities were available. In this way marketing could be spread over the winter and spring months.[70] In the

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70 Letter to the writer from Mr. E. Gilmore, Secretary, B.C. Coast Vegetable Marketing Board, Richmond, B.C.

initial years of a potato operation the acreage would have to be considerably smaller than 40 acres and gradually increased as the marketing quota was increased. In principle the situation would be the same as that encountered in establishing a marketing quota for milk.

CONCLUSIONS AND LIMITATIONS

The development of facilities at Oyster River farm has, until recently, dominated most other activities. Prior to the transfer of part of the Campus herd in 1961 there were no dairy animals at Oyster River. Since then, the size of the herd has been increased from 40 cows to nearly 100 cows. Much of the financial loss incurred by the farm may be attributed to the policy of expanding the size of the herd and necessary facilities. For example, considerable quantities of surplus milk have been shipped in an effort to increase the daily milk quota. Also, low producing cows have been retained with a view to adding to the quantity of milk shipped. It was encouraging to note, however, that the financial position of the farm improved substantially in the calendar year 1964.

Measures of financial and physical performance were calculated and compared with similar farms on Vancouver Island, in the Fraser Valley and in Washington State. Most measures of physical performance indicate that Oyster River farm is on a par with other dairy farms in the area and in the Fraser Valley. An important qualification in the case of labour efficiency is that the University pays more for its labour so that labour should be more productive. Although rates of overall performance were generally satisfactory, they tended to mask pockets of inefficiency

as was indicated by the labour study in the milking parlor.

Financial measures of performance for the Oyster River farm did not compare as favourably with the studies used for comparison. Capital investment in land and buildings (per cow) was higher though the apparent over investment in land was not a point of valid criticism in that the farm was a gift to the University. However, building investment per cow was in excess compared to similar dairy farms. Gross revenue per cow was low but may be explained by the lower percentage of quota milk. Total cash costs were nearly one half higher than in the comparative areas and may be attributed to the higher cost of labour and the higher feed costs per cow. The result was that the cost per cwt. of producing milk at Oyster River was higher than in the comparative studies and in excess of the price received. Finally, the system of farm records and accounts has not been designed to facilitate economic analysis. The financial accounts could be improved by re-classifying and refining some items of expenditure. With the exception of milk production records, physical input-output records are non-existent and herein lies one of the limitations of this assignment. For example, measures of crop response to different rates of fertilizer application have important economic implications but because of the lack of such information, its inclusion in this thesis was not possible. The question of rates of dairy feeding and rates of substitution between feeds is an unexplored area at Oyster River. Measurement of the quantity and quality of the feed consumed would provide useful information in determining the least cost ration and the optimum level of

production on the milk production surface.

The normative analysis has considered alternative methods of farm organization that showed promise of increasing net returns. Consideration was given to fifteen dairy activities, two beef activities, one sheep activity and one potato activity. Purchasing activities for labour and land were also included. The technical coefficients were defined using a combination of production functions, regional studies and synthetic budgets. Five basic analyses were chosen as embodying the most meaningful restrictions and assumptions. Two significant classifications of the analyses were made: (1) labour partially restrictive vs. labour unrestrictive and (2) consideration of all activities as above vs. a priori inclusion of 30 Ayrshire cows.

In each of the analyses activity 15 (Holstein cows) and activity 20 (potatoes) exhibited a distinct dominance over the other activities. The level at which each was recommended depended on the restrictions inherent in the particular analysis. The ranges of stability with respect to price changes were calculated and the generally wide range of stability substantiated the recommendations.

Analysis III, though not the most profitable was the more realistic. It incorporated 30 Ayrshire cows and was thus consistent with the experimental objective. It provided for labour purchasing for all periods and included consideration of all other activities. The functional was maximized at $23,324.51 to which was added the net revenue of the Ayrshire herd ($6,071.10) to yield a total of $29,324.51. After allowing for depreciation this represented a rate of return on investment of 5.8%.

A comparison of Analysis III with the less restrictive Analysis I indicated that the inclusion of 30 Ayrshire cows lowered the return to fixed factors of production by $4,074.30. In Analyses II and IV labour purchasing was restricted to the months of May, June, July, August and September. In comparison with Analyses I and III where there were no labour purchasing restrictions, the return to fixed factors was lowered. A fifth analysis was performed using higher prices for the beef and sheep activities under the conditions of Analysis III but the recommendations remained unchanged.

The recommendations of Analysis III postulate superior levels of milk production per cow but the levels are within the reach of a commercial operation and are being reached by the top cows. Potatoes are recommended to the maximum consistent with good rotational practice. It would take a number of years to implement the potato activity to its maximum due to the procedure of acquiring a sufficiently large marketing quota.

A more serious limitation is the question of the accuracy of the coefficients. It is apparent that the labour coefficients, particularly for the winter period, have been overestimated. The farm is currently caring for more cows than would be possible using the coefficients derived in this thesis. However, since the same procedure was used in defining all of the activities it is unlikely that the activities remaining in the final plan would have been different. The effect of a consistent over-estimate of the labour coefficients will be to underestimate the number of cows that can be maintained and to underestimate net returns. The

other coefficients are representative of present rates of achievement.

This thesis has attempted to evaluate the present performance of the Oyster River farm and to suggest alternative methods of organization that would improve resource utilization. The measures and models used have not been exhaustive but they are thought to lead to pertinent and useful recommendations.

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A P P E N D I X

APPENDIX 1

Valuation of Inventories.

I LAND

Land acreage was determined by a partial land survey and by using aerial photographs and a planimeter. The partial survey provided a check on the accuracy of the aerial photo technique. Land Values were determined from the land valuation schedule in the following pages.

II BUILDINGS AND EQUIPMENT

Buildings, for the most part, were valued at cost less depreciation to the present time. The rate of depreciation varied according to the type of construction, use, and degree of obsolescence. Newer equipment was valued in the same manner but older equipment was valued at market value (say at an auction sale) or scrap value. In general the following principles were followed in the valuation of buildings and equipment.

The straight-line method was used except that salvage or trade in values were not deducted from the original purchase price to obtain the total amount to be depreciated. Rather, a depreciation rate based on an estimate of the useful life of the asset was applied to the purchase price. When the asset had depreciated to its scrap or trade-in value (ie. an ex-post decision.)it was carried at this value as long as it was retained or had some use. This procedure was felt to be justified because of the uncertainty of predicting (ex ante) trade-in or scrap value. Choice of a depreciation rate was made with aview to accurately representing the capital loss of the asset. Care was taken to avoid over-

estimating the life of the asset so that in some cases it's useful life may have been under estimated. An error such as this would err on the side of conservatism and was felt to be preferable to over-estimating an asset's useful life. Thus a few assets carry a higher value than their calculated depreciated value.

2. Items were assumed to have been purchased in mid-year of the year of purchase and adjustments have been made to the nearest quarter year.

3. Depreciation rates do not necessarily coincide with income tax rates but were based on estimates of obsolescence, use and market value.

4. Major improvements to the houses were added to the depreciated value in the year the improvements were made and this new value depreciated at 2½%.

5. Asset values and depreciation charges were calculated to the nearest dollar.

6. The two Roto-Tillers have been omitted from the "operations inventory" as they are used solely for the Elite Seed Plots.

III LIVESTOCK

Livestock was valued according to fixed inventory values based on the age and class of animal. See (Appendix 5)

APPENDIX 2

LAND INVENTORY AND VALUATION

LAND				$
Lower Farm				
Total Acres	354.			
Cleared	195.6	@	$325	63,570.00
Uncleared	158.4	@	50	7,920.00
				71,490.00
Upper Farm				
Total Acres	646.			
Cleared	136.5	@	$200.	27,300.00
Uncleared	509.5	@	30.	15,285.00
Acreage South of McCaulay Road	500	@	$ 30.	15,000.00
				57,585.00
				$ 129,075.00

Farm Land Valuation Schedule Used by the Comox-Campbell River District Assessors.

LAND CLASS

1. ARABLE - no permanent limitations

Lazo loam, Merville loam, Chemainus complex (variable drainage.)

Natural Physical Features -- Limitations.

Gently sloping to sloping - well drained

Gently sloping - moderately well drained

Level to depressional - well drained

Effectively underdrained

Land Use --[1]

Cultivatable $325, $300, $275

Special Crop; Irrigated Crop $350

Rough cleared Rough Pasture $150, $100, $175

Permanent Pasture $(250), $200, $175

Unimproved $50, 40

Watch Timber

II. ARABLE - Moderate permanent limitations

Lazo sandy loam, Puntledge silt loam, Tolmie loam, sandy clay loam, and sandy loam. Alberni clay, Fairbridge silt loam to silty clay loam, Cowichan clay loam.

Natural Physical Features

Gently sloping to sloping - well drained

Gently sloping and undulating - moderately well drained

Level to gently sloping - moderately well drained

---

1 Valuation prices refer to the price per acre.

FARM LAND VALUATION SCHEDULE - NUMBER COMOX-CAMPBELL RIVER

II. ARABLE -

Natural Physical Features

Gently sloping - irregular - hummocky - well drained

Gently sloping - irregular - well drained

Level to gently sloping - moderately well drained

Slightly stony - irregular

Moderately well drained

Land Use.

Cultivatable $275, $200, $200.

Special Crop Irrigated Crop $300

Rough Cleared, Rough Pasture $135

Permanent Pasture $200, $150, $150

Unimproved $45, $40, $30

Watch Timber.

III. ARABLE - Severe permanent limitations

Cadboro gravelly sandy loam

Shawnigan gravelly sandy loam

Sandwick gravelly loam

Haslam shaly loam

Merville sandy loam

Memekay clay loam

NATURAL PHYSICAL FEATURE.

Rolling morainic - moderately stony - well drained - droughty

Gently undulating - variable amounts of gravel well drained

Gently sloping - well drained - deep solum

III. NATURAL PHYSICAL FEATURE

Gently sloping - moderately well drained

Gently sloping - well drained

Artificially drained

Fair drainage

Stone free

Land Use.

Cultivatable $240

Special drop Irrigated Crop ---

Rough cleared Rough Pasture $120

Permanent Pasture $175, $130

Unimproved $40, $30

Watch Timber

IV. SEMI ARABLE - Very severe permanent limitations

Soil type - Sproat gravelly sandy loam

Royston gravelly loam

Lazo loamy sand

Bowser loamy sand

Sayward loamy sand

Parksville sandy loam

Qualicum gravelly loamy sand and loamy sand

Natural Physical Features

Rolling - well drained - moderately stony

Undulating - well drained - moderately stony

Gently sloping - well drained

Gently sloping - imperfectly drained

Gently sloping - imperfectly drained

FARM LAND VALUATION SCHEDULE COMOX-CAMPBELL RIVER.

IV. SEMI ARABLE-

Natural Physical Features

Level - fair to poor drainage - permanent vegetation

Gently undulating to rolling - rapid drainage - droughty

Poorly drained

Excessively stony

Land Use -

Cultivatable $200, $150

Special crop, Irrigated Crop

Rough cleared Rough Pasture $100

Permanent Pasture $150

Unimproved $30

V. NON ARABLE -

Soil type - Quinsam gravelly sandy loam

Dashwood gravelly loamy sand and loamy sand

Kye gravelly loamy sand and loamy sand

Custer loamy sand

Cassidy complex

Nepturne gravelly loamy sand and sandy loam

Arrowsmith peat

Natural Physical Features

Rolling to strongly sloping - gravelly - well drained

Sloping - moderately well drained - stony - coarse texture - droughty

Gently sloping to rolling - well drained

Level to gently undulating - imperfectly drained

FARM LAND VALUATION SCHEDULE COMOX-CAMPBELL RIVER

V. NON ARABLE -

Natural Physical Features

Level to gently sloping - rapid to poor drainage - river wash

Gently sloping - well drained - coarse texture

Depressional - very poor drainage.

Land Use.

Cultivatable $175 (rarely)

Special Crop Irrigated Crop

Rough cleared Rough Pasture $100

Permanent Pasture $125

Unimproved $25 to $12 at Black Creek

Watch Rimber

Soils or soil phases stratified to this group are for the most part NON AGRICULTURAL and are only suited to a permanent type of vegetation (grazing or forestry). The soils are characterized by the rough topography, excessive stoniness, adverse drainage, low fertility, coarse texture, and extremely low moisture holding capacity. This class would also include miscellaneous land types.

APPENDIX 3

BUILDING INVENTORY 1964[2]

Description	Year Built	Initial Cost	Depreciation Rate %	Depreciation Amount $	Value Jan.1/64 $	Value Dec.31/64 $
HOUSES						
Montfort House	1945	16,000	2.5	400.00	8400.	8000.
Rm. 7 addition Frame Construction	1958					
"Wilkin" House	1945	9,500.	2.5	165.00	6187.	6022.
Major Construction	1961	900.				
House occupied by J. Wickson	1936	7,500.	2.5	147.00	5067.	4920.
Major Construction	1958	2,500.				
House occupied by R. Thuler	1948	9,500.	2.5	186.00	6800.	6614.
Major renovation	1960	800.				
House occupied by W. Staffanson	1940	8,000.	2.5	111.00	4062.	3951.
Major renovation	1960	450.				
Manager's House and office	1951	9,500.	2.5	187.00	7213.	7026.
Rms. 4 Major renovation	1962	600.				
Adamson (on beach)	1928	4,000.	2.5	100.00	450.	350.
Top Farm House	1942	3,000.	2.5	38.00	1388.	Destroyed
BARNS						
Beef Barn - pole & frame construction - concrete floor	1948	22,000.	2.5	700.00	17150.	16450.
Dairy Barn - loafing type floor with hay storage loft	1951	53,000.	2.5	1325.00	36437.	35112.
New Barn Addition	1964		2.5	—	—	12407.
Milking Parlor	1960	22,000.	5.0	1100.00	18150.	17050.

[2] Inventories for the fiscal years 1962-63 and 1963-64 have been omitted since values for these periods are linear functions of the 1964 values.

APPENDIX 3
Building Inventory (continued)

Description	Year Built	Initial Cost $	Depreciation Rate %	Depreciation Amount $	Value Jan.1/64 $	Value Dec.31/64 $
BARNS						
Bull Pen	1963	1000.	5.0	50.00	975.	925.
Machine Shop & Implement Shed	1962	4300.	2.5	107.00	4157.	4050.
Store House	1945	200.	2.5	5.00	107.	102.
Gas & Oil House	1962	250.	2.5	6.	241.	235.
Old Garage	—	50.	—	—	50.	50.
Garage & Storage Shed near Montfort House	1948	4000.	2.5	100.	2450.	2350.
Corrals, Fence Loading Platforms	1961-62	1200.	5.0	60.	1110.	1050.
6 Silos 38' x 16' L.D. included in Barns.						
Fences around fields and farmstead						
Top Farm	1948		-	-	2000.	2000.
Lower Farm Avg.	1958	19328.	6.5	1256.	11790.	10534.
TOTAL				$6043.	$134,184.	$139,198.

APPENDIX 4

MACHINERY INVENTORY
1964

	Purchase Date	Initial Cost to Farm	Depreciation Rate	Depreciation Amount	Value Jan.1/64	Value Dec.31.64
		$	%	$	$	$
POWERED EQUIPMENT						
1 3T. Truck (GMC with hoist) 1955	1961	3000.	15	450.	1875.	1425.
1 ½T. Pick-up Truck, Dodge 1956	1961	1400.	15	210.	875.	665.
1 Ford Model 2N Tractor 1949	1959	700.	10	70.	384.	314.
1 N.H. Baler #77	1950	1600.	-	-	400.	400.
1 Bull Dozer TD30 David Brown	1958	7000.	10	700.	3019.	2310.
TRAILERS						
1 5T. Hay Trailer farm made, Mat. labour @ 1.30 per hr.	1963	300.	10	30.	286.	256.
1 Silage Trailer farm made Mat. & Labour	1962	120.	10	12.	102.	90.
1 Fencing Trailer farm made.	1959	100.	10	10.	55.	45.
2 Wagons	1956	500.	10	50.	125.	75.
1 Manure Spreader New Holland	1955 N	1200.	10	120.	240.	120.
1 A.C. Forage Box farm made	1964	1075.	10	54.	-	1021.
1 Vacuum Tank farm built	1960	254.	10	25.	165.	140.

Appendix 4 - Machinery Inventory 1964

	Purchase Date	Initial Cost to Farm	Depreciation Rate	Depreciation Amount	Value Jan.1/64	Value Dec.31/64
		$	%	$	$	$
FIELD EQUIPMENT						
1 Plough (trailing Case.-2.f.)	1959	100.	7	7.	69.	62.
1 Plough (mounted M.F. new)	1955	200.	7	14.	81.	67.
1 10" Disc.Harrow	1955	150.	10	-	50.	50.
1 Zig-Zag Harrow	1958	150.	10	15.	65.	50.
1 Chain Harrow	1955	150.	10	-	25.	25.
1 Field Sweep leveller-farm built	1958	25.	-	-	25.	25.
1 Mounted Cult. M.F. (new)	1949	350.	-	-	100.	100.
1 Garden Roller	-	10.	-	-	10.	10.
1 Fertilizer Spreader, New Holland. 10'	1957	300.	7	21.	163.	142.
1 Seed Drill I.H.C. 8'	1957	200.	7	16.	108.	94.
1 Brady Forage Harv	1956 [3]	700.	7	-	49.	150.
1 Brady Forage Harv	1964	75.	7	-		
1 Brady Forage Harv	1964	500.	10	50.	-	450.
1 Mower, M.F. Semi mounted #6	1955	700.	10	-	200.	200.
1 Mower, Ford, mounted	1960	80.	10	-	80.	80.
1 Side-Delivery Rake	1959	450.	10	45.	247.	202.
1 Dump Rake; pre-war	1947	20.	-	-	20.	20.

3 The parts of two used forage harvesters were used to construct one machine for pasture clipping.

Appendix 4 - Machinery Inventory 1964

	Purchased Date (new/used)	Initial Cost to Farm	Depreciation Rate	Depreciation Amount	Value Jan.1/64	Value Dec.31/64
		$	%	$	$	$
FIELD EQUIPMENT (continued)						
1 Tedder (Hay)		30.	-	-	30.	30.
1 Hay Fleffer John Deere	1960 N	300.	10	30.	194.	164.
1 Bale Loader	1955 N	200.	7	-	88.	88.
YARD EQUIPMENT						
1 Mulkey with motor, elevator	1955	627.	7	44.	253.	209.
1 Small elevator with motor	1961	80.	7	6.	66.	60.
50 pc. 3" x 20' irrigation pipe	1962	500.	5	25.	469.	444.
1 Post-Hole Digger	1955	280.	7	-	105.	105.
1 Platform Scale	1956					
1 Fairbanks Scale	1962	3500.	2.5	87.	3368.	3281.
1-2 Wheel Sprayer	1954	450.	10	0	50.	50.
1 Air Compressor	1957	152.	7	-	81.	70.
1 Snow Plow	1958	100.	5	5.	72.	67.
1 Water Pump with engine	1956		-	-	50.	50.
1 30" Saw-Bench mounted	1957	20.	-	-	20.	20.
2 Lawn-Boys	1960 1955	70. 70.	10	7. -	46. 7.	39. 7.
2 Chain Saws	1960	300.	10	30.	194.	164.
3 Wheel Barrows 46-46-20	1955	112.	5	6.	60.	54.
1 Cow Lifter	1961	25.	5	1.	21.	20.
5 Small Motors electric	1958	25.	10	-	10.	10.

Appendix 4 - Machinery Inventory 1964

	Purchased Date (new/used)	Initial Cost to Farm	Depreciation Rate	Depreciation Amount	Value Jan.1/64	Value Dec.31/64
		$	%	$	$	$
YARD EQUIPMENT						
Cattle Squeeze	1954	270.	5	13.	143.	129.
Misc. Yard Equip. - Forks, brooms, shovels, etc.		200.	-	-	200.	200.
MILKING EQUIPMENT						
Milking Parlor Equipment	1960	6500.	10	650.	4225.	3575.
Bulk Tank	1960	3500.	10	125.	2274.	-
Bulk Tank	1964	5795.	10	290.	-	5505.
Additional, Milking Stalls	1964	2505.	10	63.	-	2442.
MISCELLANEOUS EQUIPMENT						
1 Road Drag	1957	20.	-	-	20.	20.
8 Water Troughs	1959	160.	10	8.	124.	116.
SHOP EQUIPMENT						
1 Electric Grinder	1963 U	50.	10	5.	40.	35.
2 Electric Drills	1955	50.	10)	-		
	1955 U	20.	)	-	16.	16.
1 Arc Welder	1958	300.	7	21.	184.	163.
1 Oxy-acetylene welder	1956	100.	7	-	48.	48.
1 Battery Charger	1955	25.	5	1.	14.	13.
1 Socket Set	1955	80.	5	4.	46.	42.
Other hand tools		460.	-	-	460.	460.
STORES	$					
Welding rods	50					
Nuts & Bolts	150					
Pipe & Metals	200	400.	-	-	400.	400.

Appendix 4 Machinery Inventory 1964

	Purchased Date (new/used)	Initial Cost to Farm	Depreciation Rate	Depreciation Amount	Value Jan.1/64	Value Dec.31/64
		$	%	$	$	$
NEW						
Oil fitters) Chains) Mowers parts) Belts) Tires & Tubes)		80.	-	-	80.	80.
2 Logging chains	1955	10.	-	-	10.	10.
Electric fence sets	1954	68.	5	3.	40.	37.
Bench vise	1955	20.	-	-	20.	20.
3 Grease Guns	1957	60.	10	6.	21.	15.
3 Yard jacks	1960	60.	5	3.	50.	47.
2 Grinders	1957	20.	-	-	20.	20.
TOTAL MACHINERY AND EQUIPMENT				3332.	22437.	26,922.
EQUIPMENT USED SOLELY FOR RESEARCH PROJECTS						
1 "Merry Tiller"	1961	180.	15	27.	113.	86.
1 "Mustang"Tiller	1962	220.	15	33.	168.	135.
TOTAL ALL EQUIPMENT					22718.	27,143.

APPENDIX 5

LIVESTOCK INVENTORY

CALENDAR YEAR 1964

	Accounting Value $	January 1, 1964 Number	January 1, 1964 Value $	December 31, 1964 Number	December 31, 1964 Value $
DAIRY					
COWS	425.	7	2975.	16	6800.
	350.	25	8750.	22	7700.
	250.	48	12000.	75	18750.
	170.	2	340.	-	-
	85.	-	-	-	-
TOTALS		82	24065.	113	33250.
HEIFERS [4]					
3 mos. - 12 mos.		64	5050.	54	4255.
13 mos. - 24 mos.		31	5300.	32	5500.
Bulls		1	100.	10	335.
TOTAL ALL DAIRY		178	34515.	209	43340.
BEEF					
COWS	200.	33	6600.	41	8200.
	150.	7	1050.	21	3150.
	102.	1	102.	-	
HEIFERS		15	1300.	-	
BRED HEIFERS	65.	6	390	-	
BULLS	60.	18	1080.	-	
STEERS	-	-	-	4	280.
HERD BULLS	500.	1	500.	-	
TOTAL ALL BEEF		81	11022.	66	11630.

4 The actual farm inventory sheets show a value for each 3 month age group of young stock. In this inventory the classification has been condensed.

LIVESTOCK INVENTORY 1963-64

DAIRY HERD	APRIL 1, 1963 Number	Value $	APRIL 1, 1964 Number	Value $	AVERAGE NUMBER
COWS	82	24180.	84	25270.	83.0
HEIFERS	39	9420.	47	9595.	43
Age 1-2 yrs.	35		49		42
BULLS	15	310.	2	115.	8.5
HERD BULLS	1	200.	1	200.	1
	172	$34110.	183	$35180.	X
BEEF HERD					
COWS	35	6256.	39	7500.	37
HEIFERS	22	1250.	26	1320.	24
BRED HEIFERS	18	3240.	-	-	90
BULLS	4	220.	6	510.	5.0
HERD BULLS	-		-	-	-
	97	$11486.	94	$10430.	

LIVESTOCK INVENTORY 1962-63

DAIRY HERD	APRIL 1, 1962 Number	Value $	APRIL 1, 1963 Number	Value $	AVERAGE Number
COWS	75	20510.	82	24180.	78.5
HEIFERS	61	7175.	74	9420.	67.5
BULLS	1	150.	15	310.	8.0
HERD BULLS	1	200.	1	200.	1.0
	138	$28035.	172	$34110.	
BEEF HERD					
COWS	48	5668.	35	6256.	41.5
HEIFERS	55	5000.	22	1250.	38.5
BRED HEIFERS 2 yrs.			18	3240.	9.0
STEERS			4	220.	2.0
BULLS	26	2450.	18	520.	22.0
HERD BULLS	1	350.			.5
		$13468.		$11486.	

APPENDIX 6

OPERATING STATEMENTS FOR THE CALENDAR YEAR 1964 AND THE FISCAL YEARS 1963-64 and 1962-63

OPERATING STATEMENT - CALENDAR YEAR 1964

INCOME		
Milk Sales (Gross)[5]	$	$ 46,555.92
Livestock Sales		
Dairy	3,882.57	
Beef	5,102.16	
		8,984.73
Livestock Inventory Change		
Dairy	+ 8,825.00	
Beef	+ 608.00	
		9,433.00
House Rental		1,500.00
Other Income (pulp wood)		336.39
Adjustemnts to income		
Farm Milk Consumed		
1) by employees	132.00	
2) by calves	485.76	
		617.76
TOTAL ADJUSTED INCOME		$67,427.80

Continued -

5 This represents the gross value of milk shipped prior to any deductions.

OPERATING STATEMENT - CALENDAR YEAR 1964

Continued -

EXPENSES		$
General Accounts		
Salaries and Wages		32,186.73
Employer Share of Benefits		1,899.25
Electricity		1,001.03
Insurance		1,378.42
Telephone		374.74
Fuel and Oil		1,796.88
Repairs and Maintenance		
Buildings		1,017.90
Machinery		1,393.04
Equipment Rental		2,570.06
Miscellaneous		76.76
Travelling (Farm Portion)		991.23
Livestock Accounts		
Feed		
Total Concentrate	13,763.25	
Total Hay	4,777.31	
plus opening Inventory, Jan.1 1964 2 OT at $45	900.00	
TOTAL	5,677.31	
Less Inventory Dec.31,1964	3,200.00	
Value of Purchased Hay consumed in 1964	2,477.31	
Other Supplies	699.34	
		16,939.90

Continued --

OPERATING STATEMENT - CALENDAR YEAR 1964

Continued -

EXPENSES		$	$
Professional Services			
Dairy		418.58	
Beef [6]		50.00	
Livestock Association Fees	R.O.P.		468.58
	testing		435.00
Livestock Supplies Medicines Bedding, Dairy Cleaner, etc.			
Dairy		1,225.28	
Beef		75.00	
Artificial Insemination			1,300.28
Dairy		340.43	
Beef		200.00	
			540.43
Milk Hauling			1,870.83
Dairy Association fees Milk Testing and Misc.			234.25
Crop Accounts			
Seed		222.92	
Fertilizer		1,486.13	
Other			1,709.05
TOTAL CASH EXPENSES			$68,184.36
DEPRECIATION			
Buildings		6,043.00	
Equipment		3,332.00	
FARM CONSUMED MILK		617.76	
			9,992.76
TOTAL EXPENSES			$78,177.12

6 Expenses for the beef operation are estimates since no separate account was kept of these items.

RECONCILIATION OF THE MODIFIED 1964 OPERATING STATEMENT WITH THE GENERAL LEDGER ACCOUNTS

As explained in the text the nature of the present accounting system necessitated a re-classification and revision of many income and expenditure items in order to present a truer picture of the net revenue position of the farm. As a result of these modifications the data presented in the revised operating statements differ from that in the general ledger accounts. A reconciliation of the two accounts was undertaken to account for these differences. The nature of the differences were as follows;

1. The amount shown under milk sales in the general ledger accounts is not a gross figure but is net of milk hauling, purchase of creamery shares and other creamery deductions.
2. The general ledger accounts show only cash receipts and cash expenditures with the result that changes in livestock inventories, depreciation and value of farm consumed milk are not accounted for.
3. The general ledger accounts do not provide sufficient refinement in allocating costs between the two major enterprises.
4. In some cases there has not been sufficient distinction between expenses that properly belong to the commercial operation and those that belong under the teaching and research section (especially items under account number 270).
5. Some of the income entries in the general ledger were earned in the previous year but entered in the current

5. year resulting in an overstatement for the current year.

6. Errors in tabulating resulted in an understatement of rental income.

Reconciliation of the 1964 Re-Classification Operating Statement with the General Ledger Accounts [7]

The following general ledger data was adjusted to account for the above items.

1. INCOME

Cash Income Reported in the General Ledger Accounts		$	$
Milk	(#578)	42,841.26	
Livestock Sales	(#522)	10,042.01	
House Rental	(#520)	1,004.01	
Other Income	(#523)	942.61	
Board Allowance	(#502)	220.00	
TOTAL CASH INCOME		$55,049.89	
ADD 1. Increase in inventory of livestock			9,433.00
2. Creamery deductions representing hauling, testing, dues and creamery shares.			3,714.66
3. Value of farm consumed milk			617.76
4. Understatement of rental income		$14,261.41	495.99
TOTAL		$69,311.30	
DEDUCT 1. Overstatement in "other income"			606.22
2. Board allowance			220.00
3. Excess of income under livestock sales [8]			1,057.28
		1,883.50	
TOTAL		$ 67,427.80	
OPERATING STATEMENT GROSS INCOME		$ 67,427.80	

7 Expenses for the beef operation are estimates since no separate account was kept of these items

8 This was due to Income received in 1964 for livestock sold in a previous period.

II EXPENSES Reported in the General Ledger Accounts	$	$
Total Cash Expenses	$67,434.60	
ADD		
1. Milk hauling, creamery charge (but not share purchase) 9	2,105.08	
2. Livestock supplies Medicine, dairy supplies	1,300.28	
A.I. services incurred in 1964 but paid for later	435.00	
3. Farm travel	991.23	5,371.02
		72,806.62
DEDUCT		
1. Re-allocation to non commercial activities 10	3,203.92	
2. Overstatement of feed expenses	665.83	
3. Overstatement of professional services	670.51	
4. Unaccounted overstatement of expense	82.00	4,622.26
TOTAL ADJUSTED CASH EXPENSE		68,184.36
TOTAL OPERATING STATEMENT CASH EXPENSE		68,184.36

9 The purchase of creamery shares is a capital investment not an operating expense.

10 The cash expenses for 1964 contained expenses in the amount of $3,203.92 that properly belonged under capital expenditures or under the teaching and research accounts.

OPERATING STATEMENT

1963 - 1964

	$		$
Milk Sales (Gross)			42,503.85
Livestock Sales			
Dairy	3,183.72		
Beef	4,447.10		7,630.82
Livestock Inventory Change			
Dairy	+ 1,070.00		
Beef	- 1,056.00	+	14.00
House Rental			1,500.00
Other Income			1,487.12
Adjustments to Income Farm consumed milk			
1) employees			132.00
2) calves			411.84
TOTAL ADJUSTED INCOME			53,679.63
CASH EXPENDITURES			
General Accounts			
Salaries and Wages			30,272.18
Employer Share of Benefits			1,782.81
Electricity			933.18
Insurance			1,365.04
Telephone			357.99
Fuel and Oil 1) farm use			1,611.73
2) employee use			246.44
Repairs and Maintenance			
Buildings			

Continued --

OPERATING STATEMENT 1963-64

Continued --

	$	$
Repairs and Maintenance		
Buildings	531.29	
Machinery	1,281.41	
Equipment Rental	1,732.15	
Miscellaneous (travel, office supplies, groc., cleaning, etc.)	763.65	40,877.87
Livestock Accounts		
Feed Dairy	16,042.83	
Beef	753.20	
No substantial change in Feed Inventories		
Professional Services		
Dairy	1,439.29	
Beef	50.00	489.29
Livestock Association Feed, R.O.P testing, livestock supplies (medicine, bedding, dairy cleaner, etc.)		
Dairy	1,201.85	
Beef	50.00	1,251.85
Artificial Insemination		
Dairy	137.18	
Beef		1,137.18
Milk Hauling		1,690.97
Dairy Association Fees		60.00
Milk testing and miscellaneous		23.00
		20,448.32
Group Accounts		
Seed	169.05	
Fertilizer	1,361.45	
Other		1,530.50

OPERATING STATEMENT 1963-64

Continued --

		$	$
TOTAL CASH EXPENSES			62,856.69
NON-CASH EXPENSES			
Depreciation	1) Buildings	6,667.00	
	2) Equipment	2,236.00	8,903.00
FARM CONSUMED MILK			543.84
TOTAL EXPENSES			72,303.53

OPERATING STATEMENT

1962 - 1963

INCOME:		$	$
Milk Sales (Gross)			31,863.54
Livestock Sales			
Dairy		2,890.74	
Beef		10,252.58	13,143.32
Livestock Inventory Changes			
Dairy	+	6,075.00	
Beef	-	1,982.00	4,093.00
House Rental			975.00
Other Income			596.00
Adjustments to income			
Milk Consumed by			
1) employees			132.00
2) calves			395.77
TOTAL ADJUSTED INCOME			51,198.63

CASH EXPENDITURES:	
General Accounts:	
Salaries & Wages	32,041.50
Employer Share of Benefits	1,499.72
Electricity	937.11
Insurance	1,330.83
Telephone & Office	489.28

OPERATING STATEMENT 1962-63

Continued -

	$	$
Fuel & Oil		
1) Farm use	1,666.76	
2) Employee use	78.37	1,745.13
Repairs & Maintenance		
Buildings	384.34	
Machinery	972.61	1,356.95
Equipment Rental		1,200.00
Miscellaneous (travel, office supplies, groc., cleaning, etc.)		1,526.58
		42,227.10
Livestock Accounts:		
Feed		
Dairy	11,838.55	
Beef	1,800.00	
(No substantial change in feed Invent)		13,638.55
Professional Services		
Dairy	595.97	
Beef	90.00	685.97
Livestock Assoc. Fees, R.O.P. testing, Livestock supplies, (medicines, bedding dairy cleaner, etc.)		
Dairy	1,160.34	
Beef	215.00	1,375.34
Artificial Insemination		
Dairy	64.00	
Beef		64.00

OPERATING STATEMENT 1962-63

Continued -	$	$
Milk Hauling		1,488.00
Dairy Assoc. Fees		60.00
Milk Testing & Misc.		33.33
		17,345.19
Crop Accounts:		
Seed		613.00
Fertilizer		1,471.00
Other		
		2,084.00
TOTAL CASH EXPENSES		60,656.29
NON-CASH EXPENSES		
Depreciation 1) Buildings	6,507.00	
2) Equipment	3,273.00	
FARM CONSUMED MILK	527.77	
		10,307.77
TOTAL EXPENSES		$70,964.06

APPENDIX 7

Calculations of Measures of Financial Performance For The Dairy Enterprise at Oyster River

Definitions used:

1. Gross revenue means gross dairy revenue and includes milk sales, dairy livestock sales and increase in inventory of dairy animals.

2. Total Investment includes the dairy apportionment of land, buildings and machinery plus all of the dairy cattle. The apportionment is explained in Appendix 8 and may be summarized as follows;

Land	72% of	$129,080.	$92,930.
Buildings	74% of	117,149.	86,690.
Machinery	72% of	24,034.	17,305.
Livestock	100% of	32,859.	32,859.
Total Dairy Investment			$229,784.

Investment per cow:

$$\frac{229784}{81} = \$2,837.$$

3. Building Investment per cow was calculated from Number 2 above, i.e.

$$\frac{\$86,690}{81} = \$1,070.$$

4. Machinery Investment per cow also from Number 2 above:

$$\frac{\$17,305}{81} = \$214.$$

5. Gross revenue per man-equivalent. Gross revenue has been explained above. It was necessary to standardize man-equivalents to compare with the 8 hr. work day at Oyster River. The B.C. studies used in comparison defined a

5. man-equivalent as one man working 10 hours per day for 312 days.[11] A man-equivalent at Oyster River may be defined as one man working 8 hours per day for 288 days per year. 312-10 hour days is equivalent to 390 - 8 hour days, so the ratio $\frac{390}{288} = 1.35$ was used to convert the B.C. studies to the equivalent in terms of the Oyster River definition.

6. Labour Cost per Cow was based on the labour allocation of Appendix 8

$$\frac{\$25319}{81} = \$313.$$

7. Total Cash Cost per Cow. The comparative studies treated the value of operators labour as a residual so it was necessary to add the value of this labour to the other cash expenses to make the data comparable to Oyster River. The value of the operator's labour was calculated at $4,032. and added to the cash expenses in each study. This is higher than the rate for hired wages but it seems reasonable in the light of the management responsibility involved.

8. The Cost of Producing 100 lbs. of Milk.

In the case of Oyster River the allocated expenditure $50,625. (see Appendix 8) was used, to which was added depreciation on buildings and equipment, bringing the total expense to $57,483. This was divided by the average cwt. of milk shipped (7998 cwt.) to yield a cost of $7.18. Costs of producing milk for the B.C. studies were calculated by summing total cash expenses, inventory decrease, value of unpaid family labour, value of operator labour (see above)

11 M.M. Sorboe and E.D. Woodward, Dairy Farming on Vancouver Island 1961 op. cit.; D.C. Crossfield and E.D.Woodward, Dairy Farming in the Fraser Valley of British Columbia 1961

and depreciation on buildings and equipment. This total was then divided by the cwt. of milk produced.

In the Whatcom County study operator labour was revalued at $4,032. which had the effect of raising total costs by $1,504. Interest on investment which was previously included was excluded here. Costs of production for Gray's Harbor and Lewis Counties were calculated by summing total cash expenses, value of operator labour and depreciation on buildings and equipment. Inventory changes and unpaid family labour were not applicable here.

APPENDIX 8

The Allocation of Expenditure Between the Dairy and Beef Enterprises at Oyster River Farm

The allocation of expenditures between enterprises is a somewhat arbitrary decision. Although some items can be readily identified as belonging to one enterprise or the other many can not.

The principle followed was to allocate expenditures on the basis of resources directly or indirectly consumed. For example, labour cost was allocated on the basis of the number of feed consuming animal units in each class of livestock (dairy and beef). Fire insurance and building repairs were allocated on the basis of building investment devoted to each class. Machinery expenses were allocated on the basis of the harvested forage consumed by each (since the greatest part of machinery use was connected with forage operations). In the case of electricity, telephone and miscellaneous expenses an arbitrary allocation was made. Expense totals were based on averages of the fiscal years 1962-63 and 1963-64.

The Allocation of Expenditure Between the Beef and Dairy Enterprises (Continued)

Average Expenditure 1962-63, 1963-64

ITEM	1962-63	1963-64	AVERAGE EXPENDITURE
Salaries & Wages [12]	29,891.50	26,872.18	28,381.84
Employer share of benefits	1,499.72	1,782.81	1,641.27
TOTAL COST OF WAGES			30,023.11
Electricity	937.11	933.18	935.14
Insurance	1,330.83	1,365.04	1,347.48
Telephone	489.28	357.99	423.63
Fuel & Oil Farm use	1,666.76	1,611.73	1,639.24
Empl.use	78.37	246.44	324.81
Repairs & Maintenance Buildings	384.34	531.29	457.81
Machinery	972.61	1,281.41	1,127.01
Equipment Rental	1,200.00	1,732.15	1,466.07
Miscellaneous	1,526.58	763.65	1,145.11

12 Only one-half of manager's salary is included here. The other half is attributed to the teaching research aspects of the farm.

Average Expenditures 1962-63, 1963-63
(Continued)

ITEM	EXPENDITURE 1962-63	1963-64	AVERAGE EXPENDITURE
CROP ACCOUNTS:	$ 2,084.00	$ 1,530.50	$ 1,807.25
LIVESTOCK ACCOUNTS:			
DAIRY:			
Feed	11,838.55	16,042.63	13,940.59
Prof. Services	595.97	439.29	517.63
Livestock Assoc. fees, testing, medicines, etc.	1,160.34	1,201.85	1,181.09
Milk hauling	1,488.00	1,690.97	1,589.48
Dairy Assoc. fees	60.00	60.00	60.00
Milk testing	33.33	23.00	28.16
A.I.	64.00	137.18	100.62
BEEF:			
Feed	1,800.00	753.20	1,276.60
Prof. Services	90.00	50.00	70.00
Livestock Assoc. fees, medicines, etc.	215.00	50.00	132.50
A.I.	-	-	-

SUMMARY OF THE ALLOCATION OF EXPENDITURES

AT OYSTER RIVER FARM BASED ON AVERAGES FOR 1962-63 AND 1963-64.

GENERAL ACCOUNTS	DAIRY	BEEF
1. Salaries, wages, employer share of benefits	25,318.48	4,704.63
2. Insurance	1,001.04	346.44
3. Repairs and Maintenance Buildings	340.84	116.97
Machinery & Equipment	816.74	310.27
4. Machinery Rental	1,062.46	393.61
5. Fuel and Oil	1,486.64	477.41
6. Electricity	748.11	187.03
7. Telephone	338.90	84.73
8. Miscellaneous	916.08	229.03
CROP ACCOUNTS		
9. Seed & Fertilizer	1,177.78	629.47
LIVESTOCK ACCOUNTS		
Feed	13,940.59	1,267.60
Professional Services	517.63	70.00
Assoc. fees, medicines	1,181.09	132.50
A.I.	100.62	-
Milk hauling	1,589.48	-
Dairy Assoc. Fees	60.00	-
Milk testing	28.16	-
TOTALS	$50,624.64	$8,949.69

The Basis For the Allocation of Expenditure.

1. Allocation of the Total Wage Bill (avg. $30,023.11) between the Dairy and Beef Enterprises.

The procedure followed was to apply the work unit standards used by Sorboe and Woodward to the average number of animals in the different age groups and thus obtain a measure of the division of labour. The division was further modified by taking into account differences in the quality of labor required for the two enterprises - the dairy operation requiring more highly skilled labor. The respective rates used were $14. and $12. per 8 hour day, 24 days per month.

Average Inventory of Livestock 1962-63, 1963-64.

Dairy	Average Numbers	Average A.U.S.	Work Standards per animal Annually	Total Work Units (10 hrs.)
Cows	81	80.75	13.5	1,093.5
Bred Heifers	28.5	16.94	2.0	57.0
Bulls	8.0	2.06	2.0	16.0
Herd Bulls	1.0	1.00	5.0	5.0
Heifer Calves	38.0	9.49	2.0	76.
TOTAL		110.24		1,247.5

Converting to 8 hr. work units:

1247.5 x 10/8 = 1559.37 work units

Beef	Average Number	Average A.U.S.	Standards per Animal Annually	Total Work Units (10 hrs.)
Cows	39.5	39.25	3.5	136.5
Heifers	9.	3.96	2.0	18.0
Heifers	31.	7.81	2.0	62.0
Steers	3.5	1.59	2.0	7.0
Bulls	21.	5.31	2.0	42.0
Herd Bulls	1.	1.00	5.00	5.0
TOTALS		58.92		270.5

Converting to 8 hr. work units:

$$2705 \times 10/8 = 338.12 \text{ work units.}$$

Allowing for wage rate and differences in the quality of labour we have the following;

Beef:	(338.12)	($12,)	$4,057.44
Dairy:	(1559.37)	($14.)	21,831.18
			$25,888.62

The percentage of labour utilized by each was calculated as follows:

$$\frac{4057.44}{25,888.62} \times 100 = 15.67\% \text{ used by the beef enterprise}$$

$$\frac{21,831.18}{25,888.62} = 84.33\% \text{ used by the dairy enterprise}$$

Allocation of Actual Expenditure

Dairy	84.33%	of $30,023.11	= $25,318.48
Beef	15.67%	of $30,023.11	= $ 4,704.63

2. The allocation of Insurance was based on the total building investment in each enterprise.

			DAIRY $	BEEF $
Value of Livestock, 1962-63, 63-64 Avg.			33,126.	11,717.
Building Investment, 1962-63, 63-64 Avg.				
Barns			36,768.	17,316.
Residences & Other Buildings				
Houses		$31,408.		
Other		4,441.		
		$35,849.		
This amount was allocated on the basis of labor allocation				
Dairy	84.33%		30,231.	5,618.
Beef	15.67%			
TOTAL			$100,125.	$34,651.

Total of Both $134,776.

The percentage attributable to the dairy enterprise is

$$\frac{\$100,125.}{\$134,776.} = 74.29\%$$

The beef enterprise was allocated the remainder (25.71%)

DAIRY:	74.29% of 1347.48	$1,001.04
BEEF:	25.71% of 1347.48	$ 346.44

3. Allocation of Repairs & Maintenance.

Buildings: This was allocated on the basis of the value of buildings utilized by the dairy and beef enterprises respectively. (see #1)

Dairy	$66,999.	Beef	$22,934.
Total	$89,933.		

74.45% of investment; 25.55% of investment

Total Building Repairs

$457.81

$340.84 $116.97

Allocation of Machinery Repairs : $1,127.01.

Capital investment is used as the relevant criteria here. Capital, except for milking equipment, is allocated on the basis of forage consumption of each enterprise. Since most of the equipment was oriented toward forage harvesting this seemed a reasonable guide. Only consumption of harvested forage was considered.

Normal hay production - 8000 bales @ 40.1bs = 320,000. lbs.

Normal silage production 5 silos = 582 tons.

Percentage of Feed Consuming Animal Units:

Dairy $\frac{110.24}{169.16} \cdot 100 = 65.17\%$

Beef $\frac{58.92}{169.16} \cdot 100 = 34.83\%$

Investment	Dairy	Beef
Milking Equipment	$6,286.00	-
Other Equipment		
23704. (65.17%)	15,447.89	$8,256.11
TOTAL	$21,733.89	$8,256.11

Total Machinery Investment $29,990.00

Dairy portion $\frac{21,773.89}{29,990}$ = 72.47%

Beef portion = 27.53%

Total Repairs $ 1,127.01

Dairy Portion 72.47% of 1,127.01 $816.74

Beef Portion 27.53% of 1,127.01 $310.27

4. Allocation of Machinery Rental was made on the same basis as Machinery Repairs

Total $1,466.07

Dairy 72.47% of 1,466.07 = $1,062.46

Beef 1466.07 - 1062.46 = $393.61

5. Allocation of Fuel & Oil Expense

	Beef	Dairy
Furnace oil for the dairy		$ 90.00
The remaining (1639.24 - 90) $1549.24 representing, in the main vehicle fuel, oil and grease was allocated on the same basis as the machinery investment:		
Dairy: 72.47%		$1,122.73
Beef: 29.53%	$426.51	

	Beef	Dairy
Carried Forward	$426.51	$1,122.73
The remaining fuel oil for employee use and can be considered a form of wage and can be allocated in the same manner as wages.		
Dairy: 84.33% of 324.81		273.91
Beef: 15.67% of 324.81	50.90	
TOTAL	$477.41	$1,486.64

Total of Both: $1,964.05.

Allocation of (1) Electricity	$935.14
(2) Telephone	423.63
(3) Miscellaneous	1,145.11
	$2,503.88

There does not appear to be any valid a priori basis for allocating the above expenditures. However, after considering the allocation of the other general account items a somewhat arbitrary choice was made to allocate 80% of each to the dairy enterprise and 20% to the beef.

	Dairy	Beef
6. (1) Electricity 935.14	$748.11	$187.03
7. (2) Telephone 423.63	338.90	84.73
8. (3) Miscellaneous 1145.11	916.08	229.03

9. Allocation of Crop Accounts: This was done on the basis of the proportion of feed consuming animal units. From the section on the allocation of machinery repairs this

was seen to be:

	Dairy	65.17%
	Beef	34.83%

Dairy:	65.17%	of	1807.25	$1,177.78
Beef:	1807.25	-	1177.78	$629.47

APPENDIX 9

Distribution of Tractor Time by Farm Operation 1964

TOTAL TRACTOR TIME SPENT ON FARM OPERATIONS (1964)
(HOURS)

	FEEDING	SILAGE	HAY	MANURE	FIELD WORK	FERTILIZER	MISC.	TOTAL
JUNE	55.7	196.7	33.5	8.4	6.8	8.0	38.8	348.9
JULY	74.4	155.9	107.8	17.0	9.3	20.6	42.0	430.9
AUGUST	47.0	80.0	55.4	6.0	49.9	-	50.7	289.0
NOVEMBER	20.0	-	-	108.0	38.0	-	24.0	190.0
DECEMBER	21.0	-	-	134.3	-	-	50.2	205.5

NOTE: These times were based on a study undertaken by the writer in the summer of 1964. The winter months records were kept by Mr. M. Bourdillon.

APPENDIX 10

Distribution of Tractor Time by Months Summer of 1964

	JUNE	JULY	AUGUST
		H O U R S	
Ford "Major"	142	208	77
Massey Ferguson "35"	98	107	106
Case "503"	51	51	55
Ford "2N"	58	65	51

NOTE: The annual distribution might be expected to be similar to that of figure 2 in the text.

APPENDIX 11

Cost of Operating Powered Machinery

PICK-UP TRUCK — TRUCK OPERATION — FARGO.(1955)

COST OF OPERATION

FIXED COST:

Licence:	$25.00
Insurance: (Est.)	$75.00
Depreciation: Purchased 1961 used for $1400. 15% per annum	$210.00
Interest on Investment: 5% on $700.	$ 35.00
Housing: 1/15. of Machine Shed Annual Cost	$ 6.70
Repair and Maintenance: 6.2% of Original Cost	$ 86.80
TOTAL FIXED COST	$438.50

VARIABLE COSTS

Gas: 15 Miles per Gallon at 26¢ per gal.	$0.0173 per mi.
Oil and Grease every 1000 miles	$0.0025 per mi.
	$0.0198 per mi.

COST PER MILE

MILES DRIVEN				COST PER MILE
6000 miles	$0.073	+ 0.019	=	$0.092
7000 miles	$0.063	+ 0.019	=	$0.082
8000 miles	$0.055	+ 0.019	=	$0.074

Appendix 11

TRUCK OPERATION 3-ton G.M.C. (1955)

COST OF OPERATION

FIXED COST:		
License:		$ 95.00
Insurance:		$ 75.00
Depreciation:	Purchased 1961 (used) for $3000.00 Rate 15%	$450.00
Housing:	1/15 of machine shed annual cost	$ 13.40
Interest on Investment:	5% on $1500.	$ 75.00
Repairs and Maintenance:	6.2% of original cost.	$182.00
TOTAL FIXED COST		$890.40
VARIABLE COSTS		
Gas.	10 M.P.G. @ (26+40)/2¢ per gal*	$0.033 per mile
Oil and Grease	$2.50 per 1000 miles	$ .0025per mile
		$ .0355per mile

COST PER MILE

MILES DRIVEN		COST PER MILE
6000 miles	0.150 + .035	$0.185
7000 miles	0.127 + .035	$0.162
8000 miles	0.111 + .035	$0.146

* This represents an average of farm price and the price of fuel purchased off the farm

Appendix 11

TRUCK OPERATION	FORD SUPER MAJOR Diesel
COST OF OPERATION	
FIXED COST:	
Rental	$ 356.57
Insurance: @ $10. per $1000.	35.00
Housing: 1/15 of machine shed annual cost	6.60
License:	-
Interest on Investment:	-
Maintenance: (Estimate)	50.00
TOTAL FIXED COST	$ 448.27
VARIABLE COSTS	
Fuel. .635 gal. per hr. @ 23¢ per gal.	.146 per hr.
Oil and Grease. $2.50 per 100 hr.	.025
	$ .175

COST PER HOUR

HOURS USED		COST PER HOUR
900 hrs.	0.50 + $.18	$ 0.68
1000 hrs.	0.45 + $.18	$ 0.63
1100 hrs.	0.41 + $.18	$ 0.59
1200 hrs.	0.37 + $.18	$ 0.55

Appendix 11

TRACTOR OPERATION

COST OF OPERATION	CASE 530 DIESEL WITH LOADER
FIXED COST:	
Rental:	$ 465.13
Insurance: $10 per 1000	45.00
License:	-
Housing: 1/15 of Machine shed annual cost.	6.70
Interest on Investment	-
Repairs and Maintenance: (Estimate)	50.00
TOTAL FIXED COST	$ 566.83
VARIABLE COST	
Fuel. .799 gal. per hr. @ 23¢ per gal.	.184
Oil and Grease. .025 per hr.	.025
	.209

COST PER HOUR

HOURS USED		COST PER HOUR
300 hrs.	1.89 + .209	$ 2.10
500 hrs.	1.13 + .209	1.34
600 hrs.	0.94 + .209	1.15
700 hrs.	0.81 + .209	1.02
800 hrs.	0.71 + .209	.92
900 hrs.	0.63 + .209	.84
1000 hrs.	0.58 + .209	.78

Appendix 11

TRACTOR OPERATION

COST OF OPERATION

FIXED COST :	MASSEY-FERGUSON 35 DIESEL
Rental: from invoice	$300.00
Insurance: $10 per $100 + 30	60.00
License:	5.00
Housing:	6.70
Interest on Investment:	-
Repairs and Maintenance: (Estimate)	50.00
TOTAL FIXED COST	$421.70
VARIABLE COSTS	
Fuel .546 gal. per hr. @ 23¢	.125
Oil and Grease	.025
	$.150

COST PER HOUR

HOURS USED		COST PER HOUR
500 hrs.	0.84 + .150	$ .99
600 hrs.	0.70 + .150	.85
700 hrs.	0.60 + .150	.75
800 hrs.	0.53 + .150	.68
900 hrs.	0.47 + .150	.62

Appendix 11

COST OF OPERATION

TRACTOR OPERATION

FIXED COST :		SMALL FORD 2N
Depreciation:	1950 model. purchased 1959 for $700 10% depreciation	$ 70.00
Insurance:	$10 per 1000	10.00
License:		5.00
Housing:		6.70
Interest on Investment:	5% on $350.	17.50
Repairs & Maintenance:	6.2 on original investment	43.40
TOTAL FIXED COST		$152.60

VARIABLE COST		
Fuel.	gal./hr. .513 @ 26¢ per gal.	.133
Oil and Grease		.025
		.158

TOTAL COST

HOURS USED		COST PER HOUR
300 hrs.	0.51 + .158	$ .668
400 hrs.	0.38 + .158	.538
500 hrs.	0.30 + .158	.458
600 hrs.	0.25 + .158	.408
700 hrs.	0.22 + .158	.378

Appendix 11

COST OF OPERATION

TRACTOR OPERATION
CRAWLER

FIXED COST :	DAVID BROWN T D 30
Depreciation: Purchased new 1958 $7000 Rate 10%	$700.00
Insurance: Fire, theft, & damage $10 x 3	30.00
Housing: 2/15 of machine shed annual cost	13.40
Repairs and Maintenance: 6.2% of original cost	434.00
Interest on Investment: 5% on average investment of $3500.	175.00
TOTAL FIXED COST	$1,353.40

VARIABLE COST		
Fuel.	1.0 gal per hr. @ 23¢ per gal.	$ .23
Oil and Grease.		.050
TOTAL VARIABLE COST		$ .158

COST PER HOUR

HOURS USED		COST PER HOUR
100 hrs./yr.	$13.53 + .28	$ 13.81
200 hrs./yr.	$ 6.76 + .28	7.04
300 hrs./yr.	$ 4.50 + .28	9.26
400 hrs./yr.	$ 3.47 + .28	3.75
500 hrs./yr.	$ 2.70 + .28	2.98

Appendix 11

TRACTOR HOUSING

Machine Shop & Shed. Built in 1962

Depreciation: 2½% on $4300	$108.00
Maintenance:	
Painting- 14 gal. per painting @ $5.00 per gal. ... $70.00	
Each painting lasts 4 years.	
Cost per year $17.50	17.50
	$125.50
Four-fifths of the building space is available for storage. Therefore the cost of machinery storage is 4/5 of $125.50	$100.40
There is room for 15 automobile size vehicles hence the cost per vehicle space is 100.40/15 ..	$ 6.70

TRACTOR INSURANCE

Source:

Draney Insurance Service, Campbell River

Fire, theft, damage $10.00 per $1000 per yr.

Liability on licensed tractors $30.00 per yr.

Appendix 11.

CALCULATION OF MAINTENANCE AND REPAIR ESTIMATES.

The procedure followed was to sum actual repair expenditure and a portion of the mechanics salary (64%). This total was then expressed as a percentage of the new values of all equipment including rental equipment. An exception was made in estimating repair expenditures on rented equipment. It was felt that the above method of calculation would seriously overstate repair expenses. Repair expenditure for rented equipment was estimated at $50.00.

VALUE OF EQUIPMENT

Inventory of Machinery and Equipment	$28,307.
Shop Equipment	600.
Milking Parlor Equipment	13,000.
Rented Equipment:	
Ford Major	3,566.
Massey Ferguson 35	3,000.
Case 530 and Loader	4,651.
A. C. Blower	1,500.
Manure Spreader	1,200.
TOTAL	$55,824.
Actual Repair Expenses	$ 1,139.
64% of Mechanics Salary	2,310.
TOTAL	$ 3,449.

$$\frac{3449}{55824.} \times 100 = 6.2\% \text{ of new price}$$

APPENDIX 12

The Present System of Accounts at Oyster River and a Suggested Re-classification.

The effect of the reclassification is, (1) to separate in as far as possible expenditure items by enterprise and by function e.g. dairy expenses, beef expenses, crop expenses, and capital expenses, and (2) to separate commercial expenditures from those that clearly belong to the teaching and research section. For example, account 40-9000-270 has been used for all travelling expenses and for faculty visits. Only miscellaneous expenses involving the commercial operation should be included here.

PRESENT FARM ACCOUNTS

ACCOUNT NUMBER	
40 9000	University Research Farm, Oyster River
40 9000 164	Salaries and wages
40 9000 205	Employer's share of benefits
40 9000 215	Purchases Livestock
40 9000 218	House Allowance
40 9000 224	Land Clearing
40 9000 227	Fencing and Road Maintenance
40 9000 230	Fertilizer
40 9000 234	Electricity
40 9000 238	Repairs and Maintenance (Equipment)
40 9000 240	Feed
40 9000 244	Gas and Oil

Appendix 12 Present Farm Accounts

ACCOUNT NUMBER	
40 9000 250	Insurance
40 9000 262	Repairs & Maintenance (Buildings)
40 9000 268	Seed
40 9000 270	Supplies & Expenses
40 9000 271	Vet & Drugs (Professional Services)
40 9000 272	Telephone
40 9000 278	Development of Facilities
40 9000 285	Livestock Inventory
40 9000 362	Animal Bedding
40 9000 436	Calital Equipment and rental
40 9000 520	Rentals (House)
40 9000 522	Livestock Sales
40 9000 523	Other Sales
40 9000 578	Milk Sales

TEACHING RESEARCH AND DEVELOPMENT

40 9015	University Research Farm Oyster River Teaching Research Development
Expenditure	
40 9015 274	Travel & Field Day
40 9015 278	Development of Facilities
40 9015 164	Salaries & Wages (Student Help)
Revenue	
40 9015 508	Elite Seed Sales

Appendix 12

SUGGESTED RECLASSIFICATION OF OYSTER RIVER FARM ACCOUNTS

EXPENSES

1. GENERAL ACCOUNTS:

   A. Salaries and Wages
   B. Employer Share of Benefits.
   C. House Allowance
   D. Electricity
   E. Insurance
   F. Telephone
   G. Fuel, Separated into two parts;
      i. Gas, oil, grease, and stove oil for farm operations
      ii. Stove oil used in residences of hired help
   H. Repairs and maintenance
      i. Buildings
      ii. Machinery
   I. Equipment rental
   J. Miscellaneous, travel, office supplies, groceries, laundry, etc.

2. LIVESTOCK ACCOUNTS: BY ENTERPRISE (DAIRY OR BEEF)

   A. Feed
   B. Professional services
   C. R.O.P. testing and livestock association fees
   D. Livestock supplies; drugs and medicines, bedding, flyspray, dairy cleaner, etc.
   E. A. I.

3. CROP ACCOUNTS:

   A. Seed
   B. Fertilizer
   C. Other

4. CAPITAL ACCOUNTS.

   A. Livestock purchases
   B. Machinery purchases
   C. New buildings or extensive repairs to old buildings
   D. Land development
   E. Fencing (New)

Appendix 12

REVENUE ACCOUNTS (FARM OPERATION)

1. House Rental
2. Livestock Sales — Dairy, Beef
3. Milk Sales
4. Other Income

TEACHING AND RESEARCH ACCOUNTS

REVENUE:

1. Elite Seed Sales
2. Other Income

GENERAL EXPENDITURE

1. Elite Seed Expenditure
   (Includes travelling, meals, and all other expenses of administering and maintaining the plots)
2. Field Day Expenses
3. Student Teaching Expenditure (This is Expenditure that would not have been incurred except as a result of having taught students)
4. Public Relations and Faculty Visits
5. Travelling expenses not connected with the commercial operation
6. Miscellaneous

CAPITAL EXPENDITURE

A capital expenditure account should be provided if any construction of facilities is undertaken that relate solely to the non commercial objectives.

APPENDIX 13

A Comparison of the Characteristics of Production Functions Derived by Kerr[13] for Fraser Valley data, Gossling[14] for Ontario data, Heady[15] under Iowa conditions and the Missouri Partition equation.[16]

Kerr and Gossling used the statistical method based on cross sectional data from Dairy Herd Improvement Association records in their respective areas. Kerr derived functions for Holstein cows based on 144 herds; Guernseys, (42 herds), Jerseys (33 herds) and a function for mixed herds. The number of Ayrshire herds was too small to warrant analysis. Gossling based his work on the purebred Holstein and included specified "breed factors" by which a function could be modified to represent a particular breed. Both writers have fitted transcendental and quadratic type functions to their respective data. Heady's functions were derived using the experimental method. The experiment was conducted with 36 Holstein cows for an experimental period of 26 weeks with the complete experiment conducted over a 17 month period. He fitted different algebraic forms of equations

13 T. C. Kerr, The Use and Scope of Dairy Herd Improvement Association Data in Estimating the Functional Relationship Between Feed Input and Milk Output for Dairy Cows, op. cit.

14 W. F. Gossling, "The Economics of the Holstein Friesiam Cow" op. cit.; W. F. Gossling, "The Ontario Short Run Supply Curve", op. cit.

15 Earl O. Heady and others. "Milk Production Functions, Hay-Grain Substitution Rates and Economic Optima in Dairy Cow Rations". op. cit.

16 Samuel Brody, Bioenergetics and Growth op. cit.

Appendix 13

[illegible] to the experimental data but concluded that the quadratic form served best to predict the milk production surface. Gossling used this equation in modified form in comparisons with his own and other functions. The effect of the modification was

1. to adapt the equation to cover the complete lactation plus the dry period so that the relationship represents annual inputs and outputs.
2. to transform linearly the Iowa coefficients from pounds of grain and forage to pounds of Total Digestible Nutrients from each source. (Grain at 68.63 per cent T.D.N., "Hay" at 50.65 per cent T.D.N.)

The coefficients in Kerr's functions were expressed on a daily basis and it was for this reason that the Ontario functions and the transformed Iowa functions were expressed on a daily basis (milk output divided by 305 days; feed input divided by 365 days).

The Missouri Partition equation expresses a functional relationship between T.D.N. input, output of 4% F.C.M. and body weight.

For the purpose of defining technical coefficients representative weights were chosen representing the Ayrshire and Holstein breeds (1100 lbs. and 1300 lbs respectively). It could reasonably be assumed that ΔW on an annual basis would be zero i.e. that body weight might decline during production but that it would increase during the dry period. It would then be possible to determine T.D.N. requirements given various levels of milk output, and the isoquants so obtained could be compared to isoquants

from other sources. This method was followed and the isoquants from different sources were compared. The graphical comparison is made in figures (i) to (iv).

Considering, then, the functions available (including the partition equation) the next problem was that of choosing the one or ones most appropriate. The criteria of appropriateness is defined in terms of 1) physiological characteristics of the milking cow, 2) the economic implications of the different algebraic forms of functions and 3) the applicability of the functions to the Oyster River area.

Heady states that the most logical production surface is that specified by a quadratic equation. The characteristics of such a surface are that it exhibits diminishing marginal returns as the rate of feeding increases, it has curved isoquants indicating diminishing marginal rates of substitution between the two feeds and milk production reaches a higher level on forage and concentrate than on forage alone. It is, however, possible to have isoquants that are linear or nearly linear in the middle ranges for a production surface exhibiting these characteristics. The functions derived by Kerr and Heady do, in fact, have near linear isoquants in the middle ranges. The fact that the isoquants become farther apart as production increases indicates diminishing returns.

Transcendental production functions (on the other hand) may not conform adequately to a milk production surface since

1) they assume constant elasticity of production and

2) the are characterized by linear isoclines and

increasingly wide ranges of rations for higher levels of milk production.

The most important criticism of both the quadratic and transcendental functions when they are compared with the Missouri Partition Equation is that at the lower levels of output there is simply not enough T.D.N.'s available for maintenance and production (see figure (i) to (iv)). At levels of output of 35 lbs. of F.C.M. per day and higher the partition equation isoquants fall roughly halfway between those of Kerr and those of Heady. The main criticism of the partition equation is that it does not allow for diminishing returns. Furthermore the equation does not specify the rate at which forage T.D.N. substitutes for concentrate T.D.N. However, the writer was assured by Dr. A.J. Wood of the Department of Animal Science that a linear 1 to 1 substitution rate would be realistic in the middle ranges. Notwithstanding these difficulties the Missouri Partition Equation was chosen because it more accurately specified the input requirements at each level of output.

The following equations and diagrams provide a comparison of production functions and their isoquants for the Holstein cow. In cases where the relationship was expressed on an annual basis the data were converted to a daily basis.[17] A further adjustment was necessary where milk output was expressed in terms of 3.6% F.C.M. to convert it to the equivalent of 4% F.C.M.[18] The isoquants designated "Heady" are based on Gossling's transformation of Heady's original quadratic, with a further adjustment to express the relationship in terms of daily inputs and outputs. The

17 Milk output was divided by 305 days and feed input by 365 days.

18 A linear transformation was made to express milk output in terms of 4% F.C.M.

transformed quadratic function is;

(1) $M_A = 3.0488\ H_A + 4.2931\ G_A - 0.000151\ H_A^2$
$- 0.000253\ G_A^2 - 0.000304\ H_A G_A - 5234.0$

Where M_A is annual output in lbs. of 3.6% F.C.M. and H_A and G_A are respectively annual hay and grain inputs in T.D.N.'s.

The transcendental function derived by Gossling for Ontario data was of the form

(2) $M_A = 7200 + 0.0000 H_A^{0.55414} \cdot G_A^{1.86946} \cdot e^{-0.0005447\ G_A}$

where the variables are the same as in equation (1). Gossling's quatratic function was

(3) $W = 1.4468 Z_1 + 4.1050 Z_2 - 0.01015\ Z_1^2$
$- 0.06702 Z_2^2 - 0.00343\ Z_1 Z_2 + 13.1610$

Where W is output of 3.6% F.C.M., Z_2 is the amount of grain and concentrate fed in Cwt. of T.D.N. and Z_1 is the amount of all other feed available in cwt. of T.D.N.

The quadratic function derived by Kerr was,

(1) $M = 4.53 + 3.13C + 3.09R - 0.008C^2$
$- 0.05\ R^2 - 0.085CR$

where M. is daily output of 4% F.C.M., C is daily input of T.D.N. (lbs.) in concentrate form and R is daily input of T.D.N. (lbs.) in roughage form.

The Missouri Partition Equation is

(5) Annual T.D.N. Input $= 0.305$ (annual lbs. 4% F.C.M.) $+ (0.053W)^{.73} + 2.1\Delta W$

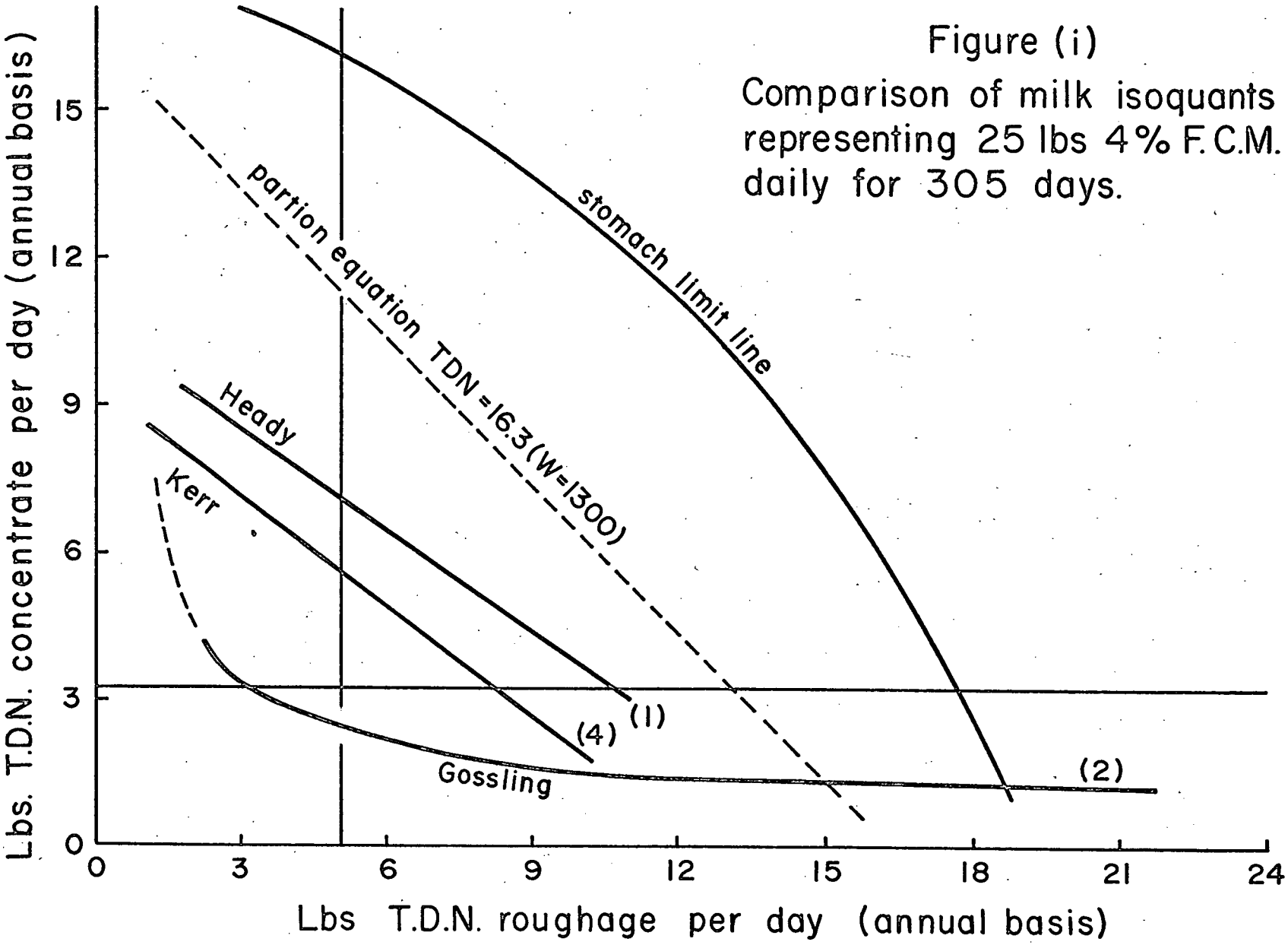

Figure (i)
Comparison of milk isoquants representing 25 lbs 4% F.C.M. daily for 305 days.

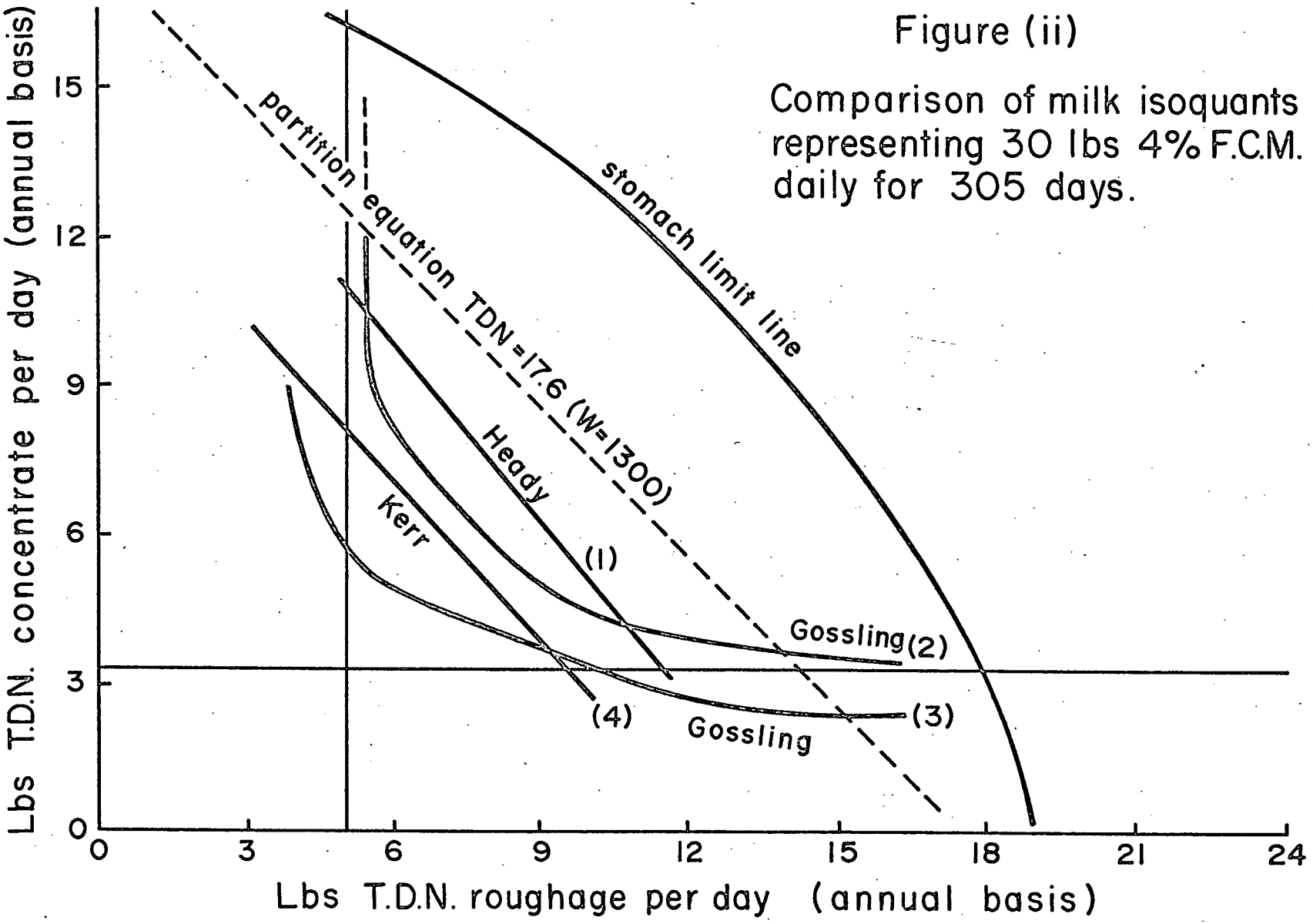

Figure (ii)

Comparison of milk isoquants representing 30 lbs 4% F.C.M. daily for 305 days.

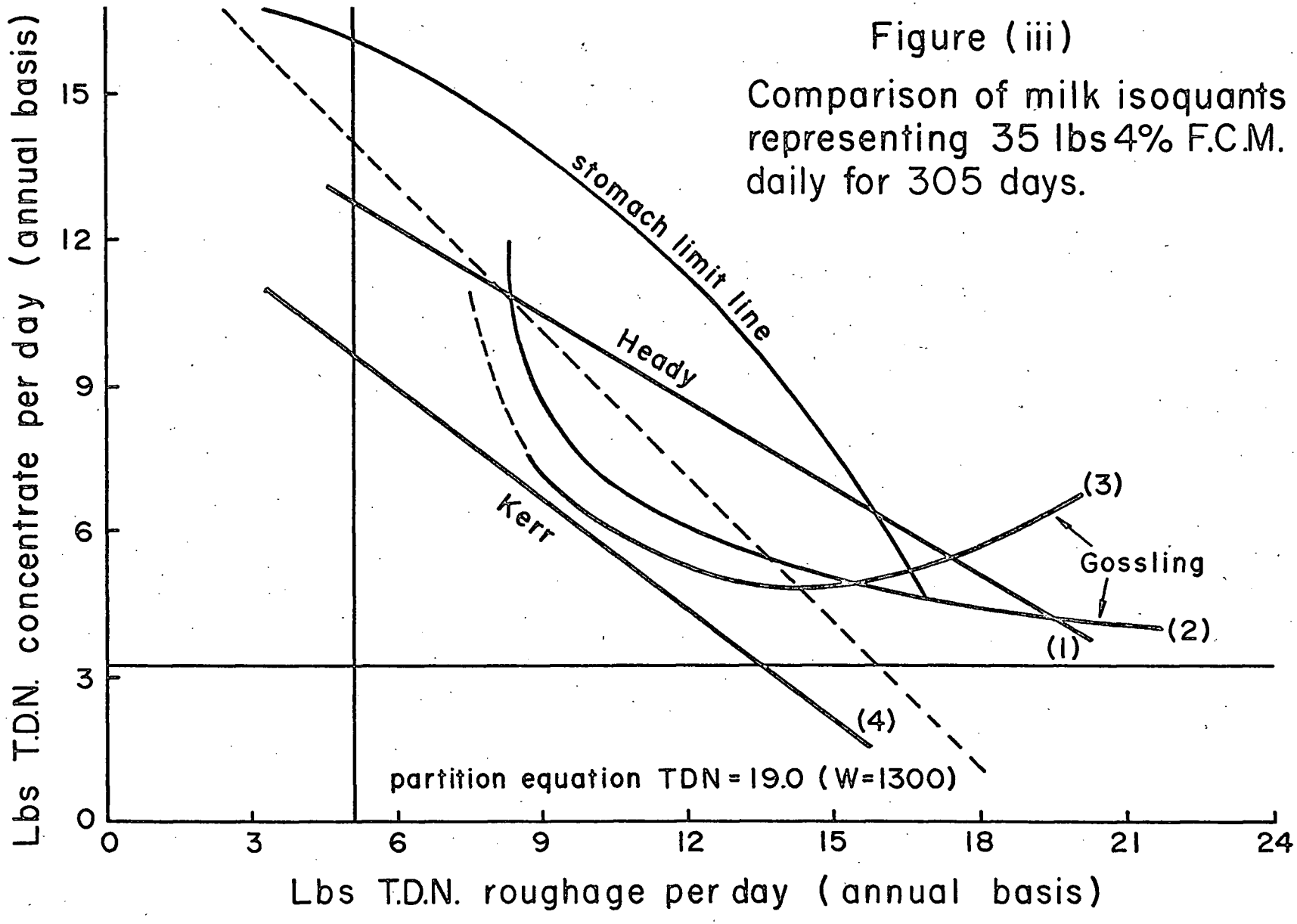

Figure (iii)

Comparison of milk isoquants representing 35 lbs 4% F.C.M. daily for 305 days.

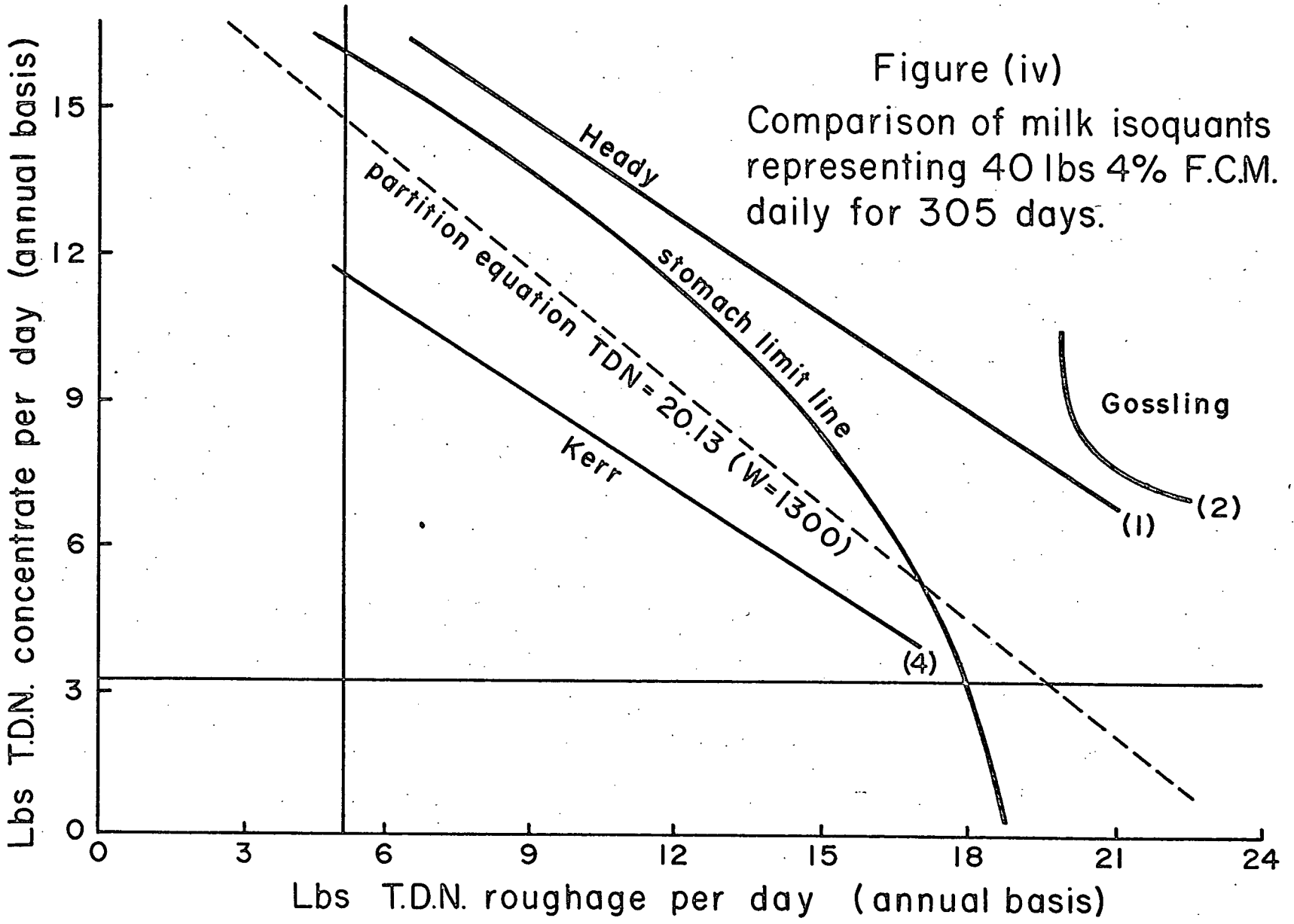

Figure (iv)
Comparison of milk isoquants representing 40 lbs 4% F.C.M. daily for 305 days.

APPENDIX 14

Calculation of Land Coefficients for the Dairy Activities.

Given the chosen points on the isoquants of figures 3 and 4 the forage requirement was converted to a land requirement. Considering forage to have a T.D.N. content of 50%, land requirements were calculated as follows:

$$\frac{\text{(Daily T.D.N. Forage req'd) (365 days) (2)}}{\text{(2000 lbs.) (2.5 tons per acre)}}$$

No distinction was made about the form in which forage was fed. It was assumed that 2.5 tons of dry matter could be obtained whether harvested as pasture, silage, hay or any combination of these. Similarly the forage requirements of the cow were not considered to be affected by the form in which it was fed. It is recognized that the form in which forage is fed has important implications in the management of a farm, but for purposes of determining total requirements and total supply it was assumed not to be relevant. Concentrate requirements, the other co-ordinate on the isoquants, are considered under the section on operating capital requirements. Having calculated the land requirements for the two representative cow weights at different levels of output and at different combinations of forage and concentrate, it was necessary to add the land requirements for the supporting young stock.

Composition of the remainder of the producing unit:

.107 heifers age 1-2 yrs. weighing 900 # each
.011 bulls age 1-2 yrs. weighing 900 3 each
.185 calves under 1 yr. of age and weighing 200 # each.

According to the Morrison standards[19] their daily requirements in terms of T.D.N. are 10.8 lbs., 10.8 lbs. and 4.4 lbs. respectively. Given these requirements the sources of T.D.N. will now be considered.

CALVES. According to Oyster River information calves receive an average of 6 lbs. of milk per day for the first 40 days. In terms of T.D.N.'s this represents 6(16.3%) = .978 lbs. per day for 40 days. Morrison further states that calves six months of age will eat about 4 lbs. of good hay per day. In terms of T.D.N.'s this is 4 (50.0%) = 2 lbs. per day for a period of 10.6 months.

As the total requirements are 4.4 lbs. of T.D.N. per day, the amount that must be supplied by concentrates is 4.4 - 2.00 = 2.40 lbs. per day also for 10.6 months. Converting this data to lbs. of actual feedstuffs we have

MILK	6 lbs. per day for 40 days	240 lbs.
CONCENTRATE	2.40 lbs. T.D.N. $\frac{(100)\ (320\ \text{days})}{69\%\ \text{T.D.N.}}$	1065.6 lbs.
FORAGE:	(4 lbs. hay) (320 days)	1280 lbs. hay

HEIFERS AND BULLS. 1-2 years of age.

Both of these classes of animals were assumed to consume the same quantities of feed. Morrison states that with abundant pasture concentrate may not be required in the summer months. In the winter feeding period 3 lbs. of concentrate is sufficient when accompanied by an abundant supply of good quality roughage. T.D.N. available from 3 lbs. of concentrate in winter feeding

(3 lbs.) (70%) = 2.10 lbs. over a 153 day feeding period the total requirement is

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19 F. Morrison. Feeds and Feeding op. cit.

(3 lbs.) (153 days) 459 lbs.

The remainder of the T.D.N. requirements must come in the form of forage.

The requirement from forage is

(10.8 - 2.10) = 8.7 lbs. T.D.N. per day for 153 days

or a total of 1331 lbs.

Converting to actual lbs. of forage we have

$$1331 \times \frac{(100)}{50.0} = 2522 \text{ lbs. forage}$$

For the remainder of the feeding period of 212 days all the requirements are met from forage.

(212 days) (10.8 lbs. per day) = 2289.6

Converting to lbs. of actual forage we have

$$2289.6 \text{ lbs.} \frac{(100)}{50.0} = 4519.$$

Total Forage required 7041.

The summary of forage and concentrate requirements for the young stock is shown in Table XXIII. The total is expressed for forage and in terms of hay equivalent.

TABLE XXIII

SUMMARY OF FORAGE AND CONCENTRATE REQUIREMENTS PER YEAR FOR THE BASIC PRODUCTIVE UNIT. (EXCLUSIVE OF THE COW).

	ANIMAL UNITS IN THE BASIC UNIT	CONCENTRATE REQUIREMENTS PER HEAD	CONCENTRATE REQUIREMENTS FOR THE BASIC UNIT	FORAGE REQUIREMENTS PER HEAD	FORAGE REQUIREMENTS FOR THE BASIC UNIT
		Lbs.	Lbs.	Lbs.	Lbs.
HEIFERS 900#	1-2 yrs. .107	459	49.11	7041.	753.4
BULLS 900#	1-2 yrs. .100	459	5.04	7041.	72.8
CALVES 200#	under 1 yr. .085	1065	90.52	1280	108.8
TOTAL			144.67		935.

The land coefficients of Table XXIV were calculated by summing the forage requirements of the cow and young stock (from Table XXIII). The total was then expressed in tons and divided by a yield of 2.8 tons of hay equivalent per acre.

TABLE XXIV

LAND REQUIREMENTS DAIRY

ACTIVITY	T.D.N. REQ'D PER DAY TOTAL (LBS.)	FORAGE PORTION (LBS.)	REQ'D ANNUALLY HAY EQUIV. (LBS.)	YOUNG STOCK	UNIT TOTAL TONS	ACRES REQ'D AT 2.8t.Hay EQUIV/AC
A_1	17.7	9.00	6570.	935.	3.752	1.340
A_2	17.7	11.40	8322.	935.	4.628	1.653
A_3	17.7	13.80	10074.	935.	5.504	1.966
A_4	19.0	9.00	6570.	935.	3.752	1.340
A_5	19.0	12.00	8760.	935.	4.847	1.731
A_6	19.0	15.00	10950.	935.	5.942	2.122
A_7	19.0	9.00	6570.	935.	3.752	1.340
A_8	19.0	12.00	8760.	935.	4.847	1.731
A_9	19.0	15.00	10950.	935.	5.942	2.122
A_{10}	21.4	8.40	6132.	935.	3.033	1.083
A_{11}	21.4	11.30	8248.	935.	4.591	1.640
A_{12}	21.4	15.00	10950.	935.	5.942	2.122
A_{13}	22.69	9.00	6570.	935.	3.752	1.340
A_{14}	22.69	12.00	8760.	935.	4.842	1.731
A_{15}	22.69	15.00	10950.	935.	5.942	2.122

APPENDIX 15

Calculation of Labour Coefficients for the Dairy Activities.

Labour coefficients were calculated using the standards of Sorboe and Woodward[20]. No information was given on the monthly distribution so it was necessary to allocate the totals by months on the basis of the writer's personal observations. For example, the feeding portion of the chore routine is much more time consuming in winter months, whereas the peak demands in harvesting forage occur in June and July. Requirements for the chore routine were calculated separately from the requirements for growing and harvesting forage.

The labour requirements for the chore routine and for growing the necessary forage were then summed by months. An adjustment factor was applied to the summer months to take account of the effect on labour requirements caused by having to grow more or less forage (as specified by the isoquants of figures 3 and 4). A similar adjustment was made to winter requirements to account for having to feed more or less forage.

A weighted average of the amount of land (remembering that there are 2 basic productivities) required to feed the producing unit was determined. It was assumed that the unadjusted standards applied to the feeding and production of forage from this average acreage. The quantity of labour required for forage is also a function of the form in which it is harvested. A normal ratio of acreage in pasture, hay and silage was determined using the following guides;

1. that pasture acreage for the milking herd be

20 M.M. Sorboe and E.D. Woodward, Dairy Farming on Vancouver Island 1961, op. cit.

as large as possible, within the limits defined by efficient forage utilization and distance from the farmstead.

2. that because of weather uncertainty in the harvesting of hay, as much silage as possible should be harvested. The upper limit in this case was the capacity of the 6 silos.
3. that the remaining acreage be allocated for hay and grazing for young stock.

Pasture is normally restricted to fields #8,#9, and #10 with a total acreage of 88.1 acres for the milking herd(See Figure 1). At a yield of 2.5 tons of dry matter per acre 63 additional acres are required to fill all 6 silos (total capacity of 157.5 tons of dry matter). With the normal hay acreage at 66.9 acres (based on actual experience) the remaining acreage available for grazing is 100.5. The data in summary form is as follows:

Pasture		188.6 acres	(62.74% of total)
Silage		63.0 acres	(18.04% of total)
Hay		66.9 acres	(19.22% of total)
TOTAL	318.5		

Applying these percentages to the weighted average land requirements expresses the normal ratio in terms of the requirements of the producing unit. Multiplying by the respective labour standards and summing, yields the total requirements for forage of the producing unit. This total was distributed by months (see figure 5) and an adjustment factor applied. Winter chore labour was similarly adjusted.

A. Standards Used by Sorboe and Woodward.

	ANNUAL REQUIREMENTS	
	10 hr. Productive - Man Work Units	8 hr. Productive - Man Work Units.
Livestock;		
Cow	13.5	16.20
Bred Heifer	2.0	2.40
Calf	2.0	2.40
Crops;		
Hay (2 crops) per acre	1.8	2.16
Silage (2 crops)	2.5	3.00
Pasture (newly seeded, top cultural practices)	0.2	0.40

B. Annual chore routine requirements for the producing unit.

1.0 cow	at 16.20	16.20 units
.244 heifer	at 2.40	.580 units
.341 calf	at 2.40	.818 units
TOTAL		17.604

C. Labour requirements for growing Forage. Calculation of the average amount of land required for the producing unit.

From the section on land coefficients it was determined that the average land requirement at a yield of 2.5 tons of dry matter per acre was 1.61 acres. (4.025 tons D.M.) A weighted average of the land required to produce 4.025 tons of dry matter seemed desirable to account for the differences in productivity between the lower and upper farm and the consequent effect on labour requirements.

The number of acres of top farm land required to support the producing unit is $\frac{4.025 \text{ tons}}{.75 \text{ tons D.M. per acre}} = 5.37$ acres

These acreage requirements (1.61 and 5.37) were then weighted by the amount of cultivated land of each type.

$$1.61 \text{ ac} \left(\frac{182.0}{318.5}\right) + 5.73 \left(\frac{136}{318.5}\right) = 3.218 \text{ ac.}$$

Using the fixed acreage ratios for pasture, hay and silage we have

Pasture	62.74% of 3.218	=	2.019
Hay	19.22% of 3.218	=	.6185
Silage	18.04% of 3.218	=	.5805

Multiplying by the work unit standards we have

Pasture	20% new	.4038	at 1.80	0.7268
	80% established	.615	at 0.50	0.0876
Hay		.6186	at 2.16	1.3359
Silage		.5805	at 3.00	1.7415
TOTAL LABOUR REQUIRED				4.612 8 hr. days

The distribution of chore routine labour (17.604-8 hr. work units) and of forage growing labour (4.612 8 hr. work units) is shown in figure 5 and in the table following. The total for each month was adjusted for the quantity of roughage specified by the isoquants of figures 3 and 4.

1. Growing the roughage;
   for each increment or decrement of one acre from the average (1.61 acres) the labour requirement was adjusted by 2.50 - 8 hr. work units in the appropriate direction. (An average of the per acre forage and hay requirements.)

2. Feeding the roughage;

for each acre change in land requirements the winter feeding coefficients (Table XXV) were adjusted by 0.07 8 hr. days per month. (Based on a change in handling requirements of 1.04 bales of hay per cow per day).

The final adjusted figures by months are presented in Table XXV.

Concentrate feeding is largely automatically handled and it was assumed that no change in labour requirements would occur due to changes in the amount fed.

TABLE XXV

LABOUR REQUIREMENTS DAIRY

8 HR.WORK UNITS

ACTIVITY	WINTER Nov.1 - Feb.28			MARCH	APRIL
	INITIAL PER MONTH	ADJUST-MENT	TOTAL 4 MONTHS		
A_1	2.0	-0.019	7.924	1.6	2.0
A_2	2.0	+0.003	8.012	1.6	2.0
A_3	2.0	+0.025	8.100	1.6	2.0
A_4	2.0	+0.008	8.032	1.6	2.0
A_5	2.0	+0.008	8.032	1.6	2.0
A_6	2.0	+0.036	8.144	1.6	2.0
A_7	2.0	-0.019	7.924	1.6	2.0
A_8	2.0	+0.008	8.032	1.6	2.0
A_9	2.0	+0.036	8.144	1.6	2.0
A_{10}	2.0	-0.037	7.852	1.6	2.0
A_{11}	2.0	+0.002	8.008	1.6	2.0
A_{12}	2.0	+0.036	8.144	1.6	2.0
A_{13}	2.0	-0.019	7.924	1.6	2.0
A_{14}	2.0	+0.008	8.032	1.6	2.0
A_{15}	2.0	+0.036	8.144	1.6	2.0

Continued -

LABOUR REQUIREMENTS DAIRY

	MAY		JUNE			JULY	
ACTIVITY	INITIAL	TOTAL	INITIAL	ADJ.	TOTAL	INITIAL	TOTAL
A_1	1.66	1.66	1.96	-.185	1.775	1.96	1.775
A_2	1.66	1.66	1.96	+.029	1.989	1.96	1.989
A_3	1.66	1.66	1.96	+.244	2.204	1.96	2.204
A_4	1.66	1.66	1.96	+.832	2.792	1.96	2.792
A_5	1.66	1.66	1.96	+.083	2.043	1.96	2.043
A_6	1.66	1.66	1.96	+.352	2.312	1.96	2.321
A_7	1.66	1.66	1.96	-1.85	1.775	1.96	1.775
A_8	1.66	1.66	1.96	+.083	2.043	1.96	2.043
A_9	1.66	1.66	1.96	+.352	2.312	1.96	2.312
A_{10}	1.66	1.66	1.96	-.359	1.601	1.96	1.601
A_{11}	1.66	1.66	1.96	+.021	1.981	1.96	1.981
A_{12}	1.66	1.66	1.96	+.352	2.312	1.96	2.312
A_{13}	1.66	1.66	1.96	-.185	1.775	1.96	1.775
A_{14}	1.66	1.66	1.96	+.008	1.968	1.96	1.968
A_{15}	1.66	1.66	1.96	+.352	2.312	1.96	2.312

NOTE: Adjustments for changes in amount of forage required are spread evenly over the months of June, July, August, and September.

LABOUR REQUIREMENTS DAIRY

	AUGUST		SEPTEMBER			OCTOBER	
ACTIVITY	INITIAL	TOTAL	INITIAL	ADJ.	TOTAL	INITIAL	TOTAL
A_1	1.96	1.775	1.46	-.185	1.285		1.6
A_2	1.96	1.989	1.46	+.029	1.489		1.6
A_3	1.96	2.204	1.46	+.244	1.704		1.6
A_4	1.96	2.792	1.46	+.832	2.292		1.6
A_5	1.96	2.043	1.46	+.083	1.543		1.6
A_6	1.96	2.321	1.46	+.352	1.812		1.6
A_7	1.96	1.775	1.46	-.185	1.275		1.6
A_8	1.96	2.043	1.46	+.083	1.543		1.6
A_9	1.96	2.312	1.46	+.352	1.812		1.6
A_{10}	1.96	1.601	1.46	-.359	1.101		1.6
A_{11}	1.96	1.981	1.46	+.021	1.481		1.6
A_{12}	1.96	2.312	1.46	+.352	1.812		1.6
A_{13}	1.96	1.775	1.46	-.185	1.275		1.6
A_{14}	1.96	1.968	1.46	+.008	1.468		1.6
A_{15}	1.96	2.312	1.46	+.352	1.812		1:6

OPERATING CAPITAL REQUIREMENTS DAIRY

ACTIVITY	PURCHASED CONCENTRATE TDNS(LBS) PER DAY	PER ANNUM	ANNUAL LBS. CONC.	ADD YOUNG STOCK	TOTAL LBS.	LABOR COST AT $62./t $	COST ANNUAL AT $14.00 $	A.I. $	MILK HAUL $	VET. SERV. MED. DAIRY SUPP. $	MACH EXP FUEL GREASE $	ELECT. TEL. MISC. $	TOTAL $
1	8.7	3175	4602	145	4747	147.16	21.39 299.38	8.00	21.35	17.89	41.54	10.19	545.51
2	6.3	2299	3332	145	3477	107.79	22.33 312.59	8.00	21.35	17.89	51.24	10.19	539.05
3	3.9	1423	2063	145	2208	68.45	23.28 328.66	8.00	21.35	17.89	60.95	10.19	515.49
4	7.0	2555	3703	145	3848	119.29	25.56 357.84	8.00	24.40	17.89	53.66	10.19	591.27
5	7.0	2555	3703	145	3848	119.29	22.56 315.90	8.00	24.40	17.89	53.66	10.19	549.33
6	4.0	1460	2116	145	2251	69.78	23.75 332.53	8.00	24.40	17.89	65.78	10.19	528.57
7	10.0	3650	5290	145	5435	168.48	21.38 299.38	8.00	21.35	17.89	41.54	10.19	566.83
8	7.0	2555	3703	145	3848	119.29	22.56 315.90	8.00	21.35	17.89	53.66	10.19	546.28
9	4.0	1460	2116	145	2261	70.09	23.75 332.53	8.00	21.35	17.89	65.78	10.19	525.83
10	13.0	4745	6877	145	7022	217.68	20.32 284.32	8.00	27.45	17.89	33.57	10.19	599.10
11	10.1	3686	5342	145	5487	170.10	22.29 312.09	8.00	27.45	17.89	50.84	10.19	596.56
12	6.4	2336	3386	145	3531	109.46	23.75 332.53	8.00	27.45	17.89	65.78	10.19	571.30
13	13.7	4997	7242	145	7387	229.00	22.38 313.38	8.00	30.50	17.89	41.54	10.19	650.50
14	10.7	3902	5655	145	5790	179.49	22.22 311.02	8.00	30.50	17.89	53.66	10.19	610.75
15	7.7	2807	4068	145	4213	130.60	21.64 302.96	8.00	30.50	17.89	65.78	10.19	565.92

APPENDIX 17

Calculation of Land Coefficients for the Beef Activities.

It was convenient to express the basic producing unit for both types of enterprises in terms of feed consuming animal units. The determination of the number of animal units in the unit of production was calculated as follows based on a 15% cull rate and a 90% calf crop.[21]

COW CALF OPERATION

	Oct.16 - Mar.14	Mar.15 - Oct.15
	A.U.	A.U.
COW	1.0	1.0
BULL 1/45	0.022	0.022
BRED HEIFER - for replacement 1/15 = .067 .067 (.44 A.U.)	0.029	0.029
CALF (.90) (.25)	----	0.225
TOTAL	1.051 A.U.S.	1.276 A.U.S.

COW YEARLING OPERATION

Totals as above	1.051	1.276
CALF	.225	already included
FINISHING STEER	-----	-.44
	1.276 A.U.S.	1.716 A.U.S.

Land Requirements

Land requirements are based on the forage needs of the producing unit. (Since all grains are assumed to be purchased.)

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21 See Page 70 of the text for the general management assumptions.

APPENDIX 17

Continued -

Forage Requirements[22]

Wintering pregnant beef cows (1000 lbs.) requires 18.7 lbs. of dry matter daily or for the winter feeding period of 152 days;

(152) (18.7) = 2842 lbs. D.M.

For the summer grazing period with the cow nursing a calf the requirement is 25 lbs. of dry matter per day for the grazing period of 213 days

(213) (25) = 5325 lbs. D.M.

TOTAL 8167 lbs.

The forage requirements per animal unit were calculated at

$$2842.4 + \frac{5325}{1.225} = 7188 \text{ lbs. of Dry Matter}$$

Requirements for a Cow Calf Operation

The annual requirements per animal unit were weighted by the number of animal units in the summer and winter periods respectively to arrive at final yearly requirements.

(1.051 A.U's.)(.416 Yr.) (7188 lbs.)

+ 1.276 A.U.'s (.584 Yr.) (7188 lbs.) = 8499 Lbs. D.M.

or 4.249 tons

Requirements for a Cow Yearling Operation

For the cow-yearling operation the calculations were as follows: (1.276 A.U.) (.416 yr.) (7188 lbs.)

+ (1.716 A.U.) (.584 Yr.) (7188 lbs.) = 11,019 Lbs.D.M.

or 5.509 tons

Land requirements at a yield of 2.5 tons of dry matter per

---

[22] Based on Morrison's, Feeds and Feeding, op. cit.

acre for

1. Cow-calf operation $\frac{4.249}{2.5}$ = 1.70 ACRES

2. Cow-yearling Operation $\frac{5.509}{2.5}$ = 2.20 ACRES

APPENDIX 18

Calculation of the Labour Coefficients for the Beef Activities.

Two sources of data were used in determining labour requirements and an average of the two was used in determining the final coefficient. The details of calculation are as follows:

Source 1. Ford Motor Company of Canada, PAYOFF TO MORE FARM PROFITS

Labour requirements for a cow-calf operation were considered under three sub-categories

(i) Cow and calf care

(ii) care for the supporting stock

(iii) growing the necessary feed for the cow and supporting stock [23]

A. Cow Calf Requirements

SUMMER

(i) Care of cow and calf 2.5 days per annum

$$2.5 - \frac{2.5}{1.5} = \frac{10 \text{ hr. days}}{.83}$$

(ii) Care of supporting stock

(.276 A.U.) (.83 days per acre) .229 days

---

23 Summer requirements were assumed to be 50% of winter requirements.

A. Cow Calf Requirements

Continued - .229 days

SUMMER

(iii) Growing forage

(1.70 Ac.) (.167 days per acre) .284 days

TOTAL 1.343 days

Converting to 8 hr. work days we have

$(1.343)\ (\frac{10}{8})$ = 1.68 days

WINTER

(i) Care of cow 10 hr. days

2.5 - .83 1.67

(ii) Care of supporting stock

(.051 A.U.) (1.67 units per A.U.) = .085

TOTAL 1.755

Converting to 8 hr. days we have

$(1.755)\ (\frac{10}{8})$ = 2.1938 8 hr. units

B. Cow Yearling Requirements

SUMMER

(i) Care of cow and calf (from previous section) .83

(ii) Care of supporting stock

(.276 A.U.) (.83) .229

(iii) Care of the Feeder Animal

(.44 A.U.) (.584 Yr.) .257

(iv) Growing the necessary Forage

2.20 Ac. at .167 days per Ac. .367

TOTAL 1.68

Converting to 8 hr. work units

$(1.68)\ (\frac{10}{8})$ = 2.10

B. Cow Yearling Requirements

WINTER	10 hr. days
(i) Care of cow	1.67
(ii) Care of supporting stock	
(.051 A.U.) (1.67 per A.U.)	.085
(.051 + .225) (1.67 per A.U.)	.461
TOTAL	2.216

Converting to 8 hr. work units we have

$$(2.216)\ \frac{(10)}{8} = 2.77 \text{ hr. units}$$

SOURCE II. Data from Economics Division, Canada Department of Agriculture.

Livestock

Beef Cows 3.5 work units per animal per yr.

Calves and heifers 2.0 work units per animal per yr.

Steers 2.0 wprk units per animal per yr.

Crops

Pasture (top cultural practics) .2 work units per acre per year.

Hay (2 cuts) 1.8 work units per acre per year.

Summer requirements for care and feeding of the producing unit were assumed to be 50% of winter requirements.

A. Cow Calf Operation.

1. Summer Requirements for;

(i) Care of the cow and calf (assumed to be identical to care of the cow alone because the calf is nursing all summer.

SOURCE II

		10 hr. work unit.
A. 1 (i)	$3.5 - \frac{3.5}{1.5}$ =	1.160

(ii) Care of supporting stock (calculated from the section on land requirements)

(.276 A.U.) (1.16 per A.U.) .320

(iii) Growing the necessary forage

(1.70 ac.) (.85 pasture) (2.W.U.) = .289

(1.70 ac.) (.15 hay) (1.8 W.U.) = .459

TOTAL 2.228

Converting to 8 hr. work units we have

$(2.228)\ \frac{(10)}{8}$ = 2.745

2. Winter labour

(i) Care of Cow 2.34

(ii) Care of Supporting Stock
(.051 A.U.) (2.34 W.U. per A.U.) = .035

TOTAL 2.375

In 8 hr. work units this is;

$(2.375)\ \frac{(10)}{8}$ =

B. Cow Yearling Operation.

Summer:

(i) Care of Cow and Calf (from above) 1.16

(ii) Care of supporting stock

(.716 A.Y.'s((1.16 per A.U.) .830

(iii) Care of feeder Animal

(.75 A.U.) (2.0 per A.U.) 1.500

SOURCE II

B. Summer:

(iv) Growing Forage

Acreage requirements 2.10[24]

Pasture (2.10)(.85)(.20 W.U. per AC.)	.357
Hay (2.10)(.15)(1.80 W.U. per AC.)	.567
TOTAL	4.414

In terms of 8 hr. work units this is

(4.414) (10/8) = 5.53

Winter;

(i) Care of Cow (from above)	2.340
(ii) Care of supporting stock	
(.051 A.U.) (2.34 per A.U.)	.119
(iii) Care of feeder animal	
(2.0 W.U.) (.584 yr.)	1.168
TOTAL	3.627

In terms of 8 hr. work units this is

(3.627) (10/8) = 4.53

---

24 It was assumed that 85% of the forage would be obtained from pasture.

SUMMARY OF LABOUR REQUIREMENTS, BEEF

Units are 8 hr. work units.

	DATA SOURCE		
	Ford Motor Company	C.D.A. Study	Average Requirement 8 hr. work units
Cow-Calf Summer	1.68	2.74	2.21
Forage only	.355	.458	.406
Winter	2.190	2.970	2.580
Cow Yearling			
Summer	2.10	5.53	3.81
Forage only	.896	1.115	1.025
Winter	2.77	4.53	3.65

The average requirements were distributed in the manner illustrated by figure 6.

APPENDIX 19

Calculation of Net Prices for the Beef Activities

GROSS VALUE OF OUTPUT PER YEAR

	$
I. Cow-Calf Operation (90% calf crop)	
Calf (.90) (450 lbs.)($.208) =	84.48
Cull cow (.15) (1100 lbs.)(#.1500) =	20.71
Steer	---
Total Value of Output	105.19
II. Cow-Yearling Operation	
Calf	------
Cull Cow (as above)	20.71
Steer (.90)(1000 lbs.)($.200) =	198.59
Total	219.30

Cattle prices were based on Calgary averages for the past five years with allowance for transportation rates to Vancouver and from Oyster River to Vancouver.

NET PRICES

I. Cow Calf Operation		
Gross Value of Output		$ 105.19
Less Variable Costs.		
a. Labour 4.788 8 hr. days at $14.	67.03	
b. Feed Concentrate	nil	
c. Professional services, medicines veterinary supplies, calculated at $14.60 per A.U. for 1.18 A.U.	17.23	
d. Machinery and fuel costs calculated at $7.67 per acre for 1.70 ac.	13.03	97.29
NET PRICE		$ 7.90

Appendix 19

II. Cow Yearling Operation

Gross Value of Output		$219.30
Less Variable Costs[25]		
a. Labour 8.465 8 hr.days at $14.	$118.51	
b. Feed Concentrate.		
Calf 1st. winter (.90) (1 lb.per day)(90 days)	2.51	
Finishing Steer (.90)(17.60 lbs. per day)(90 days)	44.19	
c. Professional services, medicines, veterinary supplies calculated at $14.60 per A.U. times 1.53 A. U.	22.34	
d. Machinery, fuel and grease calculated at 7.67 per acre for 2.20 acres	16.85	
		$204.40
NET PRICE		$ 14.73

25 Variable costs were based on Alberta farm averages since available B.C. data applied to ranch conditions. Farm Economics Branch, Alberta Department of Agriculture, Alberta Farm Business Report.

APPENDIX 20

Calculation of Technical Coefficients and Net Price for the Sheep Activity. [26]

As with other activities land requirements are a function of forage requirements. Forage requirements according to Ensminger [27] are as follows:

1. Ewes for the first 100 days of gestation require an average of 4 lbs. "medium" quality forage daily. In this case the time-period would be from November 1st tp February 9th. 400 lbs.

2. For the last 6 weeks of gestation the forage requirement is the same but an average of .625 lbs. of 14% protein concentrate is daily required

Forage (47 days) (4 lbs.) 188 lbs.

Concentrate (47 days)(.625) = 29 lbs.

3. Ewes in lactation require 4 lbs. of forage (medium quality) per day from April 1st to mid August

140 days at 4 lbs. 560 lbs

Concentrate Allowance

1.165 lbs. per day for 140 days = 158 lbs.

4. Remainder of year - only forage is fed at a rate of 4 lbs. per day.

5. The feed allowance for rams was the same as that for ewes 1121 lbs. D.M.

Forage total for ewes	1121 lbs. D.M.	
Concentrate Total for ewes	187 lbs.	
Add (.032 rams per ewe)	1121 lbs.	= 36 lbs. D.M.
and (.032) 187 lbs.	6 lbs.	
Total Forage required per ewe		1157 lbs. D.M.
Total concentrate required per ewe	193 lbs.	

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26 See page 75 of the text for general management assumptions.

27 M.E.Ensminger, The Stockmans Handbook op. cit.

Appendix 20

Land requirements at a yield of 2.5 tons of dry matter per acre are:

$$\frac{1157}{2000 \times 2.5} = .231 \text{ acres per ewe}$$

Labour Requirements Sheep

The distribution of labour requirements by months was based on an annual total of 7.5 hrs. per ewe.[28] To this was added the requirements for growing the forage fed in the winter months.

The winter feed requirements are 4 lbs. of forage per day from November 1st to February 28th or 120 days.

(120) (4.0) (.89 D.M.) = 427 lbs. D.M.

The acreage required to grow this forage is

$$\frac{427}{(2000)\ (2.5 \text{ tons per acre})} = 0.08$$

Using labour requirements of 1.8 - 8 hr. work units per acre, the additional labour, distributed over the four summer months is

$$\frac{(1.8 \text{ W.W.s})\ (0.08 \text{ A.C.})}{4} = 0.036 \text{ 8 hr. days per month}$$

The distribution of other labour took into account the peak labour demands of a sheep enterprise, namely; lambing, docking and castrating, shearing, weaning and sale.

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28 Ontario Department of Agriculture, Farm Economics and Statistics Branch. Sheep Business Report 1962

Appendix 20

LABOUR REQUIREMENTS SHEEP

8 hour work units per Ewe

	Chore Routine	Growing Forage	TOTAL
Winter Labour	0.200		0.200
March	0.200		0.200
April	0.145		0.145
May	0.104	.036	0.140
June	0.050	.036	0.086
July	0.050	.036	0.086
August	0.80	.036	0.125
September	0.050		0.050
October	0.050		0.050

OPERATING CAPITAL COEFFICIENTS SHEEP

Variable costs were calculated from budgets presented in the B.C. Department of Agriculture circular, Raising Sheep in British Columbia[29] and from a similar circular from Ontario.

1. Labour from previous Section 1.08 work units per ewe at $10.00[30] $ 10.80
2. Concentrate 193 lbs. at $62 per ton 5.79
3. Veterinary Supplies .75
4. Crop and Machinery Charges 7.67 per acre 1.76
5. Shearing .75

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29 Op. cit.

30 This is the average rate paid students

Appendix 20

Operating Capital Coefficients Sheep

	$
6. Interest and Depreciation	2.50
TOTAL	$22.35

NET PRICES SHEEP

Net prices were calculated by subtracting the variable costs from the gross value of output.

Case 1

Lamb	88.5 lbs. at $.17	$15.04
Cull Ewes	21.84 lbs. at $.05	1.09
Wool	7 lbs. at $.50	3.50
Cull Ram	150 lbs. at $.04	6.00
TOTAL VALUE		$25.63
LESS VARIABLE COSTS		22.35
		$ 3.28

Case 2

A second case was considered where the net price was increased from 3.28 to $5.00. The budget above is, in the writer's opinion, the best estimate of net price, however, it was useful to test the stability of any optional solution by postulating a reasonably higher net price. A higher net price could occur either through higher market prices or lower variable costs or a combination of both.

APPENDIX 21

Calculation of Technical Coefficients and Net Price for the Potato Activity [31]

Land Requirements.

The unit of production was defined as one acre so this was the land requirement.

Labour Requirements.

The distribution of labour requirements is based on a pre-harvest total of 20 hours per acre exclusive of winter handling estimated at 12 hours per acre, and a harvest requirement of 48 hours per acre.

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31 See page 77 of the text for a general discussion of the potato enterprise.

TABLE

MONTHLY DISTRIBUTION OF POTATO LABOUR REQUIREMENTS[32]

Time Period	Hours per Acre	8 hr. Work Units Per Acre
Winter	12	1.50
March	3	.375
April	4	.500
May	3	.375
June	3	.375
July	3	.375
August	4	.500
September	48	6.000
October		
TOTAL		10.00

OPERATING CAPITAL REQUIREMENTS[33]

1.	Labour from above 10 units at $14.00	$ 140.00
2.	Seed 11.5 cwt. at $3.50	43.75
3.	Fertilizer 450 lbs. per acre of 8-20-20	26.32

32 Labour requirements based on the publications Early Potato Production Costs and Management, Ontario Department of Agriculture, op. cit., and Potato Production Costs in Selected Areas of Central Washington 1954, Washington Agricultural Experiment Stations, Institute of Agricultural Sciences, State College of Washington, op. cit.

33 Based on personal discussions with local authorities.

Appendix 21

Continued - OPERATING CAPITAL REQUIREMENTS

4. Spraying	
Blight 9 applications of diathane M45 at 2 lbs. per acre $2.50 per trip	$ 22.50
Insects 2 applications at $2.75	5.50
5. Machinery Operating Costs including fuel, repairs, grease	21.00
6. Sacks and Twine	2.50
7. Electricity, telephone, insurance	3.00
TOTAL	$264.77

8. Trucking and marketing charges at Courtenay, $10.00 per ton.

The data following have been rounded to the nearest dollar

Operating Capital Requirements based on a yield of 12 tons per acre.

12 ton yield: 265 + 120 = $385.

CALCULATION OF NET PRICES

In calculating net prices the value of depreciation and interest on investment for buildings and equipment was added to the above.

12 ton yield 385 + 28 = $413.

The gross value of output was based on a yield of 12 tons per acre and a price per ton of $54. resulting in a gross value of $645. per acre. The net price was obtained by subtracting the variable costs from this figure.

$645. - $413. = $232.

APPENDIX 22

Additional New Investment Required for a 40 to 50 Acre Potato Enterprise.

1	Machinery [34]	$
	A. 2 - row planter	
	Cost $980	
	Depreciation 10%	98.00
	Interest on half new cost 5%	24.50
	B. Digger	
	Cost $750	
	Depreciation 10%	75.00
	Interest on half new cost at 5%	18.75
	C. Sprayer	
	Cost $500	
	Depreciation 10%	60.00
	Interest on half new cost at 5%	15.00
	D. Cultivator	
	Cost $425	
	Depreciation 10%	42.50
	Interest on half new cost at 5%	10.65
	E. Potato handling and grading equipment	
	Cost $1000	
	Depreciation 10%	100.00
	Interest on half new cost at 5%	25.00
	TOTAL MACHINERY COST	$469.40

34 Prices were based on the quotations of a local implement dealer.

Appendix 22

POTATO BUILDING INVESTMENT REQUIRED

The assumed requirements were 80 per cent of a 16 ton per acre crop with 40 acres in crop.

(16) (40) (80) = 512 tons

Space requirements are 860 sq. ft. (10 ft. deep) per 100 tons plus alley space estimated at $\frac{1}{4}$ of 860. The total requirement is 1075 sq. ft. The requirement for 40 acres from above is (1075) (5.12) = 5504 sq. ft.

Estimated Cost $2.50 per sq. ft.	or	$13,760.
Depreciation 2½%		344.
Interest on half new cost at 5%		344.
		$ 688.
Cost per Acre Machinery and Buildings		$1,157.40

$$\frac{1157.40}{40} = \$28.03$$

APPENDIX 23

Forage Mixtures at Oyster River Farm.

Field No. 1	Adjacent to elite seed plots	
	Perennial rye grass	
Field No. 2	Seeded 1959	
	Red Clover	480 lbs
	Ladino Clover	120 lbs
	Orchard Grass	360 lbs
	Alta Fescue	300 lbs
	Perennial Rye Grass	240 lbs
Field No. 3	Seeded 1960	
	Highland pasture mix	1000 lbs
	U.B.C."Special" grass clover mix	1000 lbs
Field No. 4 Field No. 5	Seeded 1959	
	Perennial Rye Grass	240 lbs
	Alta Fescue	240 lbs
	Orchard Grass	640 lbs
	Red Top	240 lbs
	Red Clover	480 lbs
	Ladino Clover	160 lbs
		2000 lbs
Field No. 8	Two mixes	Seeded 1962

Appendix 23 - Forage Mixtures

Field No. 8 — Two mixes — Seeded 1962

North Half		South Half including No. 6	
Orchard grass	240	Tall fescue	300
Red Clover	140	Ladino Clover	80
Kentucky Blue grass	60	Kentucky Blue grass	80
White Dutch clover	60	White Dutch clover	40
	500 lbs		500 lbs

Field No. 7	Seeded 1961	
	Alfalfa	200 lbs
	Red Clover	160 lbs
	Orchard grass	240 lbs
	Alta Fescue	200 lbs
	Rye Grass	240 lbs
	Red top	160 lbs
Field No. 9	Seeded 1958	
	Perennial Rye grass	480 lbs
	Alta Fescue	240 lbs
	Orchard Grass	480 lbs
	Red top	240 lbs
	White Dutch Clover	320 lbs
Field No. 10	Seeded 1964	
	Orchard Grass	300 lbs
	Ladino clover	40 lbs
	Alsike clover	40 lbs

Appendix 23 - Forage Mixtures

Field No. 10	Seeded 1964	
	Red top	40 lbs
	Reed Canary grass	80 lbs
TOP FARM		
Low Bench		
	Red clover	300 lbs
	Ladino clover	240 lbs
	Orchard grass	300 lbs
	Alta Fescue	300 lbs
	Perennial Rye Grass	36- lbs

The remainder of the top farm is native grass.

Note that weights of each grass variety indicate proportions in respect to the total mix, they do not represent actual amount seeded on a given field. In addition the mixtures listed, oats or combinations of oats, peas and vetch were seeded at the same time and harvested for silage (except the top farm).