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Linear programming is now widely accepted and used by researchers and industrial management people, but its adoption by farm managers has been slow. This study concentrates on the development of improved data transmittal techniques for farm organization linear programming. The program model is designed to analyze crop production alternatives.

Models presently in use were studied for 1). restriction and activity format and 2). data transmittal input and output techniques. In spite of the availability of linear programming models, the lack of input and report generating programs has limited the application of linear programming as a practical farm management tool.

Input forms and computer reports were designed for ease of use and interpretation by farm managers. The system was then

programmed by the Oregon State University Computer Center and tested for practical application on a case farm. Various problems appeared which required a redesign of the forms and computer reports. A "Cooperators Manual" was then written to explain the system to potential users.

After several program changes, the system was tested on six selected farms. The farmers completed the forms for their operations indicating the resources available and the crop activity coefficients. The farmers, after receiving the computer reports, completed a questionnaire stating their experiences and thoughts regarding this farm planning system. A record was kept of the farm manager's time in filling out the input forms. Computer processing cost for each farm was also recorded.

The farm managers were generally quite receptive to this method of systematized budgeting. They all indicated that they planned to implement at least part of the suggested organization. It was found that records, of some description, were needed in going through the process of completing the forms. County agents and published data can also be used in the information-gathering process.

This study reveals that data transmittal techniques can be developed such that farm managers can communicate readily with the computer. Better communication will make other technical tools, in addition to linear programming, useful in modern farm busines management.

Data Requirements and Transmittal Techniques for Applied Farm Organization Linear Programming

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DATA REQUIREMENTS AND TRANSMITTAL TECHNIQUES FOR APPLIED FARM ORGANIZATION LINEAR PROGRAMMING

INTRODUCTION

Primary Management Task

Farm organization is one of the primary problems of the farm manager. What crops and livestock to produce and in what combinations are important management decisions. While farm organization has always been a problem in the history of cultivated agriculture, it is more important currently because of the rapidly changing technical and economic environment (6). Planning and organization are critical to the future of the farm business.

Because of climate, soil and market conditions, there are over 100 different enterprises available to Willamette Valley farmers (12). These range from intensive crops such as tree fruits and irrigated vegetable crops to non-irrigated grains and grass seeds. According to a 1967 study by Lange, some of the enterprises are complementary, some are supplementary, but most are competitive with respect to the factors of production. There are also alternative methods of production which can be employed with many of these enterprises. Irrigated vs. non-irrigated wheat is an example. Capital requirements vary depending on the enterprise and cultural practices followed. Price relationships between crops also change over time.

For example: Red clover seed in Marion County in 1968 sold for $38/cwt. and in 1969 for $40/cwt. White clover during these two years went from $50/cwt. in 1968 to $40/cwt. in 1969 (13). Given the large number of possible enterprise combinations, price fluctuations, and changes in production techniques, farm organization decisions can become very time consuming and frustrating.

New Management Technology

Management technology, in the form of linear programming, has been developed and is being used quite extensively in research and by non-farm firms (4). This mathematical technique has proven effective in solving cost minimizing and profit maximizing problems. It was first used in solving logistic problems by the United States Air Force in the latter 1940's. United States industries now use it for such things as least cost routing of trains, trucks, and aircraft and for determining the best cuts to make on different size logs given market demand and supply for wood products. A detailed mathematical description of linear programming is not attempted as this has been adequately done many times (8, 10, 15).

Use of Linear Programming in Farm Management

Linear programming as an optimizing tool may be used for many types of farm planning problems. Reorganization of existing resources on a farm is one use of this tool. A farmer may recombine his resources considering the same enterprises or reorganize considering new enterprises. Currently there is a lot of interest in developing irrigation systems on farms. Irrigated crop activities may be considered using linear programming to gain insight into the profitability of irrigation development.

Another example of where farm planning is required is the case of a manager taking over the operation of a different farm with resources and activities somewhat unfamiliar to that manager. All of the production activities of the area need to be considered for the farm's organization. The manager may also be concerned about the income potential of the farm in making decisions as to the wisdom of the investment and the debt repayment capability of the operation.

Because of economies of size, many commercial farmers are now buying or leasing more land to expand their resource base. Evaluations need to be made as to the farm's organization with these expanded resources and the profitability or increased returns to management which is likely with expansion. In various parts of the country, farmers are pooling their resources to gain economies of size and other advantages. When all of the land, labor, machinery, etc., of the operations are combined, it is obvious that organization and planning are necessary.

These and other types of management problems require decisions to be made. Linear programming for farm planning appears to be one method of helping solve some of these rather complex problems. There are also farmers who are just interested in the experience and education they might derive from going through this process on their farms.

Linear programming for farm planning has been used with varying degrees of success. It has been used to a limited extent on individual farms and for education purposes by universities (9). Probably the most impressive use of linear programming for individual farm organization has been the Rapid Adjustment Farm Project of the Tennessee Valley Authority. "Rapid Adjustment" farms were picked by the Extension Service, programmed, and then used as demonstration farms for agricultural development (9). Farm organization linear programming has been used as a teaching device at the University of Kentucky for approximately 15 years. Pennsylvania State University, the University of Missouri, and others have developed programs for individual farm planning. More recently, Purdue University has developed an "Automatic Corn Budget" for use in the Top Farmer Program (5). Yet, with all this effort, there have been very few commercial attempts to utilize linear programming as a tool for decision making on individual farms (14). Doanes Agricultural Service attempted to apply the technique to individual farm problems but discontinued the service because the cost, from $1000 up, was higher than farmers were willing to pay (17).

The Problem

Linear programming is now widely accepted as an effective management tool. It is used extensively in research and in industrial management, but its rate of adoption by farmers has been slow. There are several possible reasons why farmers have not used this management tool more extensively: 1) The relatively high cost of professional services and computer time to do effective planning on an individual farm basis; 2) This service has not been made available because universities and/or the extension service has shied away from the personal service aspects of programming individual farms; 3) Extensive training has been required of those collecting the data, processing the computer programs, and interpreting the results; 4) Easy to use input techniques have not been developed, nor has much effort been spent designing linear program computer reports that can be read and understood by farmers.

The computer requires information in a very precise and orderly manner. Specific communication languages have been developed and have been learned and/or modified by those using the machine for research and industrial management purposes. So far, however, farm managers have been pretty much by-passed by developments which would aid them in understanding the computer as a management tool. A communications system between the farmer and the computer has not been developed in such a way as to encourage use of the computer by farmers.

Purpose

This study concentrates on the development of input and output techniques in the use of linear programming for farm planning problems. It is felt that many of the problems of using this tool would be overcome if there were better communications and understanding between the farmer and the computer. The problems of gathering data are difficult enough without having additional frustrations because of poor data handling techniques. Farm managers are confused even further by reports which need considerable explanation and interpretation by highly trained personnel. Present techniques make the mass application of linear programming for individual farms impractical. If input and output techniques were developed which farmers could understand, linear programming would be much easier for these managers to use as a planning tool.

The objective of this research is to determine whether input and output techniques can be developed which will encourage adoption of linear programming as a management tool for farmers. This is accomplished by first determining what set of data is needed to give practical and useful results for crop farm organization planning.

The next step is to develop input forms for collecting this data and design a computer report to be returned to the farmer. Then, this system is tested on farms to find out how difficult the input process is and how well the final reports are understood.

This effort will be limited to the development of a crop farm model because it has broader application for Oregon's commercial agriculture and is sufficient to test the hypothesis. When the application techniques of less detailed models are mastered, then others, such as crop-livestock models, may be tackled.

Procedure

Existing linear programming models were reviewed for the input and output techniques used and their applications to Oregon agriculture. Such programs as those developed by the University of Missouri (18), Pennsylvania State University (7), the University of New England (Armidale, Australia) (1), International Business Machines Corporation (used at the University of Arizona) (3) and Oregon State University's Computer Center were analyzed for their relevancy. After examining the various programs, it seemed that those used at the University of Arizona and Oregon State University offered some ideas which might have practical application for programming individual farms. An initial set of data was defined for programming these farms, and a set of input forms was developed which were designed to be filled out by farmers. A first attempt was then made at laying out a computer report which could be returned to the farmer for his use. The input form and report layout were taken to the computer center for programming. When the system finally appeared operational, data from a case farm were processed. The report and input forms were discussed and studied with the case farm's manager. This revealed many difficulties and the input forms and output reports were remodeled. A "Cooperator's Manual" was also written to explain how to fill out the input forms and how to interpret the computer report.

Input forms were then distributed to managers of six selected test farms. With the aid of county agents, these operations were chosen as being different from each other and with managers which had enough interest to follow through with this study. The Cooperator's Manual was also given to them to be used as an aid in filling out the forms. After about two weeks' time, the forms were gathered and the data processed through the programs. The reports were returned and discussed with each of the six farmers. Questionnaires were then filled out by these farm managers to measure their difficulty in completing the input forms and their understanding and acceptance of the computer report. A record was kept of the key punch and computer processing costs for each of the six test farms.

THE INPUT SYSTEM AND ITS DEVELOPMENT

Input Forms

Within the constraints of developing easy to read and use input and output techniques, one of the objectives of this study was to determine what data are needed to do meaningful farm organization linear programming on crop farms. The value of the final report depends on the accuracy and completeness of this input information. The data used are dictated by that which are available and that which are needed by the program model.

A set of standardized forms is used in transmitting this data from the farm manager to the computer center. Two different input forms are used in collecting information for the program. The first, which will be called the "resources available" form provides data (right hand side information) on acres of land, hours of labor, operating capital, etc., for the farm's operation. The second, "crop budget" form, provides data on each crop (activity information) considered for the farm's organization. One of these crop budget forms is completed for each crop considered.

Various criteria were used in the development of these forms. As well as supplying the information necessary for the program, the forms had to be in laymen's terms so that they were easy to understand and use by farmers. The forms also had to meet certain specifications so that they could be processed by key punch operators. These requirements will be dealt with in the following explanation of the forms.

A Willamette Valley farm, herein referred to as the "Ole Nelson Farm," was used along with its manager in testing the forms and the computer programs for probable changes. This farm had an excellent set of enterprise records as a data source. The manager had three to four years of experience with data processing and was very receptive to cooperating in this development. The case farm was picked because of these factors and proved to be a valuable asset in this endeavor.

Input Form Changes

Many changes were found necessary in the development of the input forms. The original plan was to have two management levels for crop activities. These were indicated on the form as Management I and Management II. It was anticipated that the Management I level would be chosen for those with experience in the production of the crop and would be likely to receive higher yields thus a larger gross margin. Management II was to be used for crops not grown on the farm before or those with which the manager was not experienced. It was felt that these factors might give lower production levels and a smaller gross margin making the crop relatively less likely to be included in the farm's organization.

When this separation was put to a practical test it was found to be confusing to the farm managers and of little value. So, instead of having this separation, which essentially constitutes a different activity, the level of management of the farmer and the farm's capabilities are accepted and help determine the yields and costs expected. If a manager wants to consider a crop, say bush beans, and has never produced them before, this can be taken into account when filling in the yield and cost information.

The model has three land rows or land classifications for separation of soils according to their productivity. Based on a study of soil types and productivities (11), it was assumed that the following classification would meet the requirements for programming crop farms. Flood plain or bottom soils would usually be classified as Land I, terrace or bench soils as Land II, and upland or hill soils as Land III. Although this is the way land is usually classified for the program, any applicable scheme may be used for a particular farm. For example, Land I could be used for irrigated acres, Land II for dry land, and the Land III class left unused.

Of the six farms used to test out the system after it was developed, only one farm operator said there should be more land classifications. Two of the six farms used only one land class, one used two land classes and three used all three land classes. The operator who felt a need for more land classes had been trained to think in terms of soil types and had a hard time reorienting himself to three classifications. Even though land on different farms is not classified the same, it appears that three classes for any one farm is sufficient if not more than adequate.

Certain design changes had to be made in the forms to facilitate key punching and program processing. The first time the key punch office handled the input forms the data were punched incorrectly, and difficulties arose concerning the order of the information on the forms relative to the order in which it was processed by the computer program. The forms (pages 13 and 14) were then changed so that rather than having straight lines, ______, on which to write data the lines were divided into sections thusly; |_|_|_|_|_| and where necessary, decimal points were indicated thusly; |_|_|_^_|_| so that the data were presented for key punching in a more precise manner. The order in which the program processes crop data is the order in which the data are found on the crop budget form (page 14). The first form used had the variable cost section further down on the form. This along with other input items was reoriented on the form so that the data could be punched in the order of the computer program's requirements for data.

On the top of this form (page 14) there is a line for calculating gross returns per acre. This is done simply by multiplying yield

COMPUTERIZED FARM PLANNING

Resources Available

Farm Number ____________ Name: ____________

Address: ____________

Restricting Resources Available:

Land I : ________ acres, use value: $ ________ /acre

Land II : ________ acres, use value: $ ________ /acre

Land III: ________ acres, use value: $ ________ /acre

Operating Capital: $ ________ Use Value: ________ / $

Labor (Hrs.): Use Value $ ________ / hr.

Jan. ________ Feb. ________ Mar. ________ Apr. ________

May ________ June ________ July ________ Aug. ________

Sept. ________ Oct. ________ Nov. ________ Dec. ________

Water (acre inches) Use value: $ ________ / acre inch

Apr. ________ May ________ June ________ July ________

Aug. ________ Sept. ________ Oct.-Mar. ________

Crop Enterprises to be considered in the farm organization

Enterprise	Yield Units	Price/ Unit	Minimum Acres	Maximum Acres

COMPUTERIZED FARM PLANNING

Crop Budget (per acre basis)

Farm Number: ______________ Crop Name: ______________

Gross Returns Yield ________ x price ______ + govt. pay ______ = ______________

Variable Costs

Machinery & Equipment	$______________
Fertilizer	______________
Spray & Dust	______________
Seeds & Plants	______________
Supplies	______________
Other Cash Expenses	______________
______________	______________
Total Variable Costs	$______________

Gross Return less variable costs ______________

Resources Used:

Land Class: [ ] (1, 2, or 3)

Acreage limitation on this crop (if any)

Minimum: ________ acres Maximum: ________ acres.

Operating Capital: $ ______ (for one acre)

Labor in Hours:

Jan.	______	Feb.	______	Mar.	______	Apr.	______
May	______	June	______	July	______	Aug.	______
Sept.	______	Oct.	______	Nov.	______	Dec.	______

Irrigation Water in Acre Inches:

Apr.	______	May	______	June	______	July	______
Aug.	______	Sept.	______	Oct.-Mar	______		

COMPUTERIZED FARM PLANNING

Processing Set Up Information

Run Control Card

Crop Enterprises to be considered in this run

Enterprise	Crop ID.	Yield Units	Price/ Unit	Standard Deviation

times price and adding a government payment if one is received. The variable costs are then itemized, totaled, and subtracted from the gross returns to get returns after variable costs (gross margin).

The bottom section of this form is for indicating the resources required for each crop acre. Acreage restrictions (both minimum and maximum) may also be entered for each crop. This feature was designed to be used for crops which have acreage limitations due to government programs, marketing contracts, and/or rotation restrictions.

The resources available form (page 13) was also revised because of changes in data requirements and organization. When use values were added, the dollar and cent values had to be reported into the program through the input forms. The logical place was on the resources available form adjacent to the appropriate resource. This was done by using the line and markings; └┴┴┴┴┘ to insure more accuracy in transmitting data.

A third form (page 15) is filled out by the person administering the program. This form provides general information for processing. A "control card" provides data on the standard deviation on prices, number of crops, year of analysis, and other control information. There is also a header card for each crop. This card provides the specific name of the crop used in the program, the yield units, the price expected, and the standard deviation of this price. Details on the use of this information will be explained in the next chapter (Chapter III).

Use Values

In the process of working with the Ole Nelson Farm it became apparent that it might be meaningful to add "use values" for the practical application of this linear programming model. When these values are included (with the present matrix set up), the assumption is that there is truly an opportunity cost for the restricting resources. (If there is no opportunity cost for these resources, a zero value should be used.) Ole Nelson stated that there was a minimum rate per hour at which he was willing to work for the farming operation. He claims an opportunity cost for his labor in off-farm employment and leisure time. If a use value was not inserted for this labor, the linear programming model could use this input to the point where virtually nothing is earned for the last few hours worked. By including some positive value, a minimum return is established for the use of labor.

The same argument applies for setting a minimum percentage on operating capital, a minimum value on the use of land and a minimum value on irrigation water. If land designated as class I on a farm can be rented out for $30 per acre (after taxes), this should be the use value for this land. Then, if the land doesn't earn at least $30 per acre in the program, it will not be included in the organizational plan. This implies that because of the restrictions of other resources the land should be rented out rather than forcing an organization which would use all the land. Use values on land can also be inserted when considering renting additional acreage. Using this technique, the program report will show whether it would be profitable to rent more land. The use value for operating capital is in terms of a minimum percentage acceptable for this capital whether owned or borrowed and dollars per acre inch for irrigation water.

Filling in the Forms

Questionnaires were filled out by the six farm managers on whose farms the input and output techniques were tested. The average length of time spent by these operators was 4.2 hours, with a range from 2.5 hours to 5.5 hours. They all indicated that the forms were easy to use but that in some cases the information needed was not readily available.

Questions were also asked about where the information was obtained when filling out the forms. Their answers varied so greatly that no tabulations were attempted. Records, experience, and judgment were the most common answers with a few relying quite heavily on the county extension office for input information by those with little or no records.

Table 1. Summary of Questionnaire Results

Question	Farm Number 1	2	3	4	5	6
1. How many hours did it take to gather the information and fill out the input forms?						
a. 1-2 hours						
b. 2-3 hours	x					
c. 3-4 hours					x	
d. 4-5 hours		x		x		x
e. 5-6 hours			x			
2. Where did you obtain the following information? (Records, county agent, publication materials, etc.)	Records	Records	Records and experience	Records and judgments	Records and experience	County agent and records
a. Variable costs on each crop?						
b. Labor by month on each crop?						
c. Irrigation water by month on each crop? .						
d. Operating capital used on each crop? . . .						
e. Yield for each crop?						
f. Price for each crop?						
3. How well did you understand the printout when you first looked at it?						
a. Not at all						
b. Somewhat	x				x	
c. Fairly well		x	x	x		x
d. Completely						
4. How much better did you understand it after it was explained? (How much explanation needed?)						
a. Explanation did not improve my understanding						
b. Explanation was needed on certain items .	x	x	x	x	x	x
c. Explanation was necessary on all items . .						
5. What action will you take regarding the solution the program suggests for your farm organization?						
a. Ignore it						
b. Implement part of it	x	x	x	x	x	x
c. Implement all of it						

Table 1. (Continued)

Question	Farm Number 1	2	3	4	5	6
6. Explain your answer to No. 5						
a. Impractical solution because of input				x[2]		
b. Impractical solution because of other reason					x[1]	
c. Personal dislike for organization suggested	x					
d. Apprehensive about outcome						
e. I feel the organization will make me more money than my present plan	x	x[1]	x[1]			x[3]

[1]Change inputs and process again considering other alternatives.

[2]Not enough land classifications.

[3]This farm had a resident manager and he did not make organizational decisions.

Model Description

The system developed involves a generalized crop-farm model. Although the coefficients are different for each individual farm, the matrix structure is the same for all farms. The only mechanical difference among farms is the number of columns or activities as this is flexible and depends on the needs of each operation. (There is no set limit as to the number of activities that may be considered for each farm.) The program generates a matrix based on the information provided on the input forms. The model constraints and activity requirements are as follows:

Model constraints:

1. Acres of land; three classifications
2. Minimum and maximum acreage limitations (bounds) for each crop
3. Annual operating capital
4. Labor in hours for 12 monthly periods
5. Irrigation water in acre inches for seven time periods

Crop activities (requirements per acre):

1. Gross margin calculations
    a. yield and price
    b. government payment
    c. total variable costs

2. Land classification designation

3. Operating capital needed

4. Monthly labor use

5. Irrigation water needed by time period

The objective of the model is to maximize annual income given the cropping alternatives, the resources available and the opportunity costs of these resources. When included, use value amounts become variable costs and affect the gross margins of the crop activities. Caution should be exercised in designating use values as they should be at their opportunity cost and can affect the solution. The program computes three farm plans from three different sets of prices.

DEVELOPMENT AND DESCRIPTION OF THE FARM PLANNING REPORT

General Approach

One of the primary objectives of this work was to develop a linear programming report that would be easily understood by farmers. Research workers generally are familiar enough with the computer and the languages used to communicate directly with the machine, whereas most farm managers are not acquainted with these technicalities and require a method of communications with which they are familiar (5). A major source of cost in doing linear programming for individual farms has been the time and work involved in interpreting the solutions to the farmers (14). Therefore, before large-scale farm planning can be accomplished, computer report generator procedures must be developed. This chapter describes one such attempt using a crop farm linear programming model.

The original layout of the report was developed in conjunction with the input forms. With the data provided through the input system, the "Computerized Farm Planning Report" (pages 29 through 32) was finally developed. The report generator routine carries out the tasks of interpreting the solution and preparing the report which is described below.

The report is four pages in length. The first page of the report redefines the resources available on the farm as submitted on the input forms. The last three pages of the report offer suggested solutions given different price conditions.

The first step in the report development was to study existing linear programming reports. None of these reports had been designed to be read and understood by laymen. The L. P. report processed by Oregon State University's Computer Center seemed to be general enough to handle the activity and resource restriction data on the input forms (16). This report was redesigned using tables and alphabetic descriptions.

Resources and Alternatives

The purpose of the first page of the report (page 29) where the resources available and alternative activities are defined is to provide a summary description of each individual farm. This is a handy reference page in reviewing the input information. For the Ole Nelson Farm example 480 acres of Land II were available with a use value of $35/acre. Since the land on the farm was fairly uniform in quality, land classes I and III were not used. In completing the input form, Nelson has also indicated that he can obtain a maximum of $75,000 operating capital with a use value of 10%. Also listed are the hours of labor available each month with a use value of $1.50/hour, and the acre inches of water available at $1.00/acre-inch use value. The bottom section of the page provides information on the crop enterprises considered. These may be crops that are presently grown on the Nelson Farm or others that he would like to consider. Acreage constraints, both minimum and maximum, are also reported. These limits are included to facilitate restrictions due to government programs, acreage contracts on certain crops, established perennial crops, or for other reasons which might restrict acreages. The three price levels for each crop are listed (P_1, P_2, and P_3) along with the production per acre of these crops. The gross return per acre under each price level is the respective price times the yield and the net return per acre is the return after variable costs or the gross margin.

Price Levels

The program is designed to compute a solution under three different sets of prices: P_1, P_2, and P_3. Price level P_1 is a set of prices normally expected during the planning period in question. These prices may be those expected by the farmer for a statistical approach may be used based on historical prices. Price level P_2 is a set of low prices and price level P_3 is a set of high prices. One standard deviation from the mean price, P_1, is used to determine price levels P_2 and P_3. While it is recognized that all prices will not change in the same direction at the same time, this technique does offer three solutions for each farm programmed. This technique will provide some measure of stability of the mean price solution given lower or higher prices.

The three different solutions are designed to show what the suggested crops and acreages are when prices change. When testing the system on farms, the managers were most interested in the solution under average or expected prices and appeared less concerned about the solutions under low or high prices. This was expected, but there still is value in the other reports because of the thought process the farmers go through and the orientation involved when establishing the different prices and price levels.

Solution Reports and Interpretation

Page 30 of the report is the programmed solution under price level P_1. Some reorganization was done and additional information added in the process of developing this section of the report. The resources used: land, operating capital, labor, and irrigation water, are printed under columns headed "Used." The resources not needed for the programmed solution are printed in the "Unused" columns. When all of a resource available is used in the solution, the program calculates a shadow price. A shadow price is a value indicating the amount by which returns would increase if one more unit of the resource were available. For example, all 1,000 hours of labor available in March was used in the solution and a $5.08 shadow price was computed. Therefore, if one more hour of labor were available in March, returns would increase by $5.08. The shadow prices suggest which resources are limiting on the farm and to what degree they limit the operation.

Next on the page is the programmed solution or the "Optimum Enterprise Combination Under Price Level 1." For easy reference the acreage restrictions are printed after the crop names. The next column gives the acreage of the crops suggested as the optimum solution. On the Nelson operation, wheat is in the plan at the maximum acreage of 250 acres, cauliflower is in at about 17 1/2 acres, and so on down the list of crops. Two crops out of the ten considered, chewings fescue and alfalfa, are not in the solution.

The "Opportunity Cost" column gives a value at which returns/acre would increase if additional acres of the crops listed could be grown. On wheat there is an opportunity cost of $11.09, indicating that if the acreage restriction were increased one acre (to 251), returns would increase by $11.09. The opportunity cost is calculated much like the shadow price but is a value on additional acres in the solution restricted by acreage limitations, whereas the shadow price indicates the amount returns would increase if an additional unit of a resource were available. The "Total Return" column is calculated by multiplying the acreages in the solution times the returns per acre. For wheat there are 250 acres. Multiplying this times $66.90 per acre gives \$16, 725. The addition of this column gives a "Return (after variable costs)" to the programmed solution of \$68, 318.44. The table in the lower left of the page gives the "Total Value of Restricting Resources Used" of \$34, 138.76 (based on the assumed use values). This is calculated by multiplying the units of resources used times the use values. Four hundred eighty acres of land II were used in the solution. At \$35 per acre, there is a charge of \$16, 800. Subtracting the total value of restricting resources used from the return after variable costs gives \$34, 179.68. From this, fixed or overhead costs which have not been accounted for may be subtracted to give a return to management.

The table showing the calculations on the value of the restricting resources used is an addition to the original format. This was added to make a "Return to Management" easier to calculate. A return to management was found to be much more meaningful to farmers than a return after variable costs. In the Nelson Farm example (page 30), the return after variable costs is \$68, 318.44. After subtracting the value of the restricting resources used, \$34, 179.68 remains. When he can see all of the resources accounted for, it is much easier for a farmer to understand the solution. It is also more meaningful to compare the return to management figure from one report to another for a farm when changing prices or the resource levels.

COMPUTERIZED FARM PLANNING REPORT

FARM NUMBER 3603001 OLE NELSON FARMS 1970 PROGRAM FOR 1970 10/29/70

*** RESTRICTING RESOURCES AVAILABLE ***

LAND 1	ACRES	LAND 2	480 ACRES	LAND 3	0 ACRES	OPERATING CAPITAL 75000
$	/ACRE	$	35/ACRE	$	0/ACRE	OPERATING CAPITAL AT 10%

HOURS OF LABOR
COST $ 1.50/HR.

JANUARY	450	FEBRUARY	1000	MARCH	1000	APRIL	1000	MAY	1500	JUNE	2450
JULY	2000	AUGUST	2000	SEPTEMBER	1000	OCTOBER	1000	NOVEMBER	450	DECEMBER	450

ACRE-INCHES OF WATER FOR IRRIGATION
PRICE $ 1.00/ACRE-INCH

APRIL	300	MAY	300	JUNE	300	JULY	300	AUGUST	300	SEPTEMBER	300

OCTOBER THRU MARCH 300

*** ENTERPRISES TO BE CONSIDERED ***

CROP ALTERNATIVES	ACREAGE MIN.	ACREAGE MAX.	PRICE PER UNIT P1	P2	P3	PRODUCTION PER ACRE	GROSS RETURN PER ACRE P1	P2	P3	RETURN PER ACRE P1	P2	P3
WHEAT	0	250	45.00	42.50	47.50	2.0 TON	90.00	85.00	95.00	66.90	61.90	71.90
CAULIFLOWER	0	35	130.00	104.00	156.00	4.0 TON	520.00	416.00	624.00	358.70	254.70	462.70
STRAWBERRIES	14	35	.17	.15	.19	9000.0 LBS	1530.00	1350.00	1710.00	769.60	589.60	949.60
FESCUE CHEWINGS	0	150	.18	.14	.22	400.0 LBS	72.00	56.00	88.00	48.35	32.35	64.35
BLACKBERRIES MA	5	10	.14	.12	.16	10000.0 LBS	1400.00	1200.00	1600.00	676.20	476.20	876.20
BLACKBERRIES EV	0	10	.14	.12	.16	10000.0 LBS	1400.00	1200.00	1600.00	660.00	460.00	860.00
SUGAR BEET SEED	0	15	.20	.17	.23	2000.0 LBS	400.00	340.00	460.00	326.20	266.20	386.20
ALFALFA	0	30	25.00	21.60	28.40	5.0 TON	125.00	108.00	142.00	76.00	59.00	93.00
CLOVER CRIMSON	0	100	.19	.15	.23	500.0 LBS	95.00	75.00	115.00	58.00	38.00	78.00
DIVERTED ACRES	65	100	40.00	40.00	40.00	1.0 ACRE	40.00	40.00	40.00	35.00	35.00	35.00

*** USE OF RESTRICTING RESOURCES UNDER PRICE LEVEL 1 ***

RESOURCE	USED	UNUSED	SHADOW PRICE
LAND 1	0	0	-0
LAND 2	480.00	0	5.18
LAND 3	0	0	-0
HOURS OF LABOR			
JANUARY	110.40	339.60	-0
FEBRUARY	780.00	220.00	0
MARCH	1000.00	0	5.08
APRIL	711.82	288.18	-0
MAY	312.54	1197.46	-0
JUNE	2450.00	0	6.37
ACRE-INCHES OF WATER			
APRIL	0	300.00	0
MAY	103.96	196.04	-0
JUNE	197.71	102.29	-0

RESOURCE	USED	UNUSED	SHADOW PRICE
OPERATING CAPITAL	25280.99	49719.01	-0
HOURS OF LABOR			
JULY	1152.78	847.22	-0
AUGUST	1024.61	975.39	-0
SEPTEMBER	657.84	342.16	-0
OCTOBER	1000.00	0	4.45
NOVEMBER	88.08	361.92	-0
DECEMBER	0	450.00	-0
ACRE-INCHES OF WATER			
JULY	227.96	72.04	-0
AUGUST	207.96	92.04	0
SEPTEMBER	155.96	144.04	-0
OCT.-MAR.	0	300.00	0

*** OPTIMUM ENTERPRISE COMBINATION UNDER PRICE LEVEL 1 ***

ENTERPRISE	ACREAGE MIN.	ACREAGE MAX.	USED	OPPORTUNITY COST	RETURN PER ACRE	RETURN TOTAL
WHEAT	0	250	250.00	11.09	66.90	16725.00
CAULIFLOWER	0	35	17.62	-0	358.70	6318.82
STRAWBERRIES	14	35	26.98	-0	769.60	20764.25
FESCUE CHEWINGS	0	150	0	-3.24	48.35	0
BLACKBERRIES MA	5	10	10.00	180.07	676.20	6762.00
BLACKBERRIES EV	0	10	8.38	0	660.00	5533.21
SUGAR BEET SEED	0	15	15.00	202.77	326.20	4893.00
ALFALFA	0	30	0	-2.50	76.00	0
CLOVER CRIMSON	0	100	87.02	0	58.00	5047.15
DIVERTED ACRES	65	100	65.00	-16.30	35.00	2275.00

RETURN (AFTER VARIABLE COSTS) $ 68318.44

RESOURCES	USED	USE VALUE	COST
LAND 2	480.00	35.00	16800.00
OP. CAP.	25280.99	.10	2528.10
LABOR	9278.07	1.50	13917.11
WATER	893.55	1.00	893.55

TOTAL VALUE OF RESTRICTING RESOURCES USED $ 34138.76 — 34138.76

DIFFERENCE $ 34179.68

OVERHEAD COSTS ---------

RETURN TO MANAGEMENT

*** USE OF RESTRICTING RESOURCES UNDER PRICE LEVEL 2 ***

RESOURCE	USED	UNUSED	SHADOW PRICE
LAND 1	0	0	-0
LAND 2	394.02	85.98	-0
LAND 3	0	0	-0
HOURS OF LABOR			
JANUARY	23.37	426.63	-0
FEBRUARY	780.00	220.00	-0
MARCH	1000.00	0	2.04
APRIL	717.18	282.82	-0
MAY	310.07	1189.93	-0
JUNE	2450.00	0	4.26
ACRE-INCHES OF WATER			
APRIL	0	300.00	0
MAY	106.14	193.86	-0
JUNE	200.94	99.06	-0

RESOURCE	USED	UNUSED	SHADOW PRICE
OPERATING CAPITAL	22826.31	52173.69	-0
HOURS OF LABOR			
JULY	1119.49	880.51	-0
AUGUST	942.73	1057.27	-0
SEPTEMBER	485.75	514.25	-0
OCTOBER	1000.00	0	2.03
NOVEMBER	87.95	362.05	-0
DECEMBER	0	450.00	-0
ACRE-INCHES OF WATER			
JULY	229.96	70.04	-0
AUGUST	209.96	90.04	-0
SEPTEMBER	158.05	141.95	-0
OCT.-MAR.	0	300.00	0

*** OPTIMUM ENTERPRISE COMBINATION UNDER PRICE LEVEL 2 ***

ENTERPRISE	ACREAGE MIN.	ACREAGE MAX.	ACREAGE USED	OPPORTUNITY COST	RETURN PER ACRE	RETURN TOTAL
WHEAT	0	250	250.00	15.20	61.90	15475.00
CAULIFLOWER	0	35	17.59	-0	254.70	4479.95
STRAWBERRIES	14	35	28.07	-0	589.60	16549.95
FESCUE CHEWINGS	0	150	0	-12.86	32.35	0
BLACKBERRIES MA	5	10	10.00	89.16	476.20	4762.00
BLACKBERRIES EV	0	10	8.37	0	460.00	3848.13
SUGAR BEET SEED	0	15	15.00	161.27	266.20	3993.00
ALFALFA	0	30	0	-8.07	59.00	0
CLOVER CRIMSON	0	100	0	-12.71	38.00	0
DIVERTED ACRES	65	100	65.00	-9.01	35.00	2275.00

RETURN (AFTER VARIABLE COSTS) $ 51383.03

RESOURCES	USED	USE VALUE	COST
LAND 2	394.02	35.00	13790.85
OP. CAP.	22826.31	.10	2282.63
LABOR	8916.52	1.50	13374.79
WATER	905.04	1.00	905.04

TOTAL VALUE OF RESTRICTING RESOURCES USED $ 30353.32 30353.32

DIFFERENCE $ 21029.71

OVERHEAD COSTS

RETURN TO MANAGEMENT

*** USE OF RESTRICTING RESOURCES UNDER PRICE LEVEL 3 ***

RESOURCE	USED	UNUSED	SHADOW PRICE
LAND 1	0	0	-0
LAND 2	480.00	0	17.56
LAND 3	0	0	-0
HOURS OF LABOR			
JANUARY	123.50	326.50	-0
FEBRUARY	786.63	213.37	-0
MARCH	1000.00	0	8.00
APRIL	704.89	295.11	-0
MAY	301.93	1198.07	-0
JUNE	2450.00	0	8.40
ACRE-INCHES OF WATER			
APRIL	0	300.00	0
MAY	103.61	196.39	-0
JUNE	197.42	102.58	-0

RESOURCE	USED	UNUSED	SHADOW PRICE
OPERATING CAPITAL	25363.43	49636.57	-0
HOURS OF LABOR			
JULY	1165.43	834.57	-0
AUGUST	1026.04	973.96	-0
SEPTEMBER	671.78	328.22	-0
OCTOBER	1000.00	0	6.69
NOVEMBER	89.74	360.26	-0
DECEMBER	0	450.00	-0
ACRE-INCHES OF WATER			
JULY	229.40	70.60	-0
AUGUST	209.40	90.60	-0
SEPTEMBER	156.51	143.49	-0
OCT.-MAR.	0	300.00	0

*** OPTIMUM ENTERPRISE COMBINATION UNDER PRICE LEVEL 3 ***

ENTERPRISE	ACREAGE MIN.	ACREAGE MAX.	ACREAGE USED	OPPORTUNITY COST	RETURN PER ACRE	RETURN TOTAL
WHEAT	0	250	236.75	0	71.90	17022.12
CAULIFLOWER	0	35	17.95	0	462.70	8304.87
STRAWBERRIES	14	35	26.81	-0	949.60	25456.00
FESCUE CHEWINGS	0	150	0	-0.75	64.35	0
BLACKBERRIES MA	5	10	10.00	267.58	876.20	8762.00
BLACKBERRIES EV	0	10	8.50	-0	860.00	7307.41
SUGAR BEET SEED	0	15	15.00	237.56	386.20	5793.00
ALFALFA	0	30	0	-4.08	93.00	0
CLOVER CRIMSON	0	100	100.00	5.58	78.00	7900.00
DIVERTED ACRES	65	100	65.00	-30.72	35.00	2275.00

RETURN (AFTER VARIABLE COSTS) $ 82720.41

RESOURCES	USED	USE VALUE	COST
LAND 2	480.00	35.00	16800.00
OP. CAP.	25363.43	.10	2536.34
LABOR	9319.94	1.50	13979.91
WATER	896.33	1.00	896.33

TOTAL VALUE OF RESTRICTING RESOURCES USED $ 34212.58 34212.58

DIFFERENCE $ 48507.83

OVERHEAD COSTS ---------

RETURN TO MANAGEMENT

The last two pages of the report, page 31, the solution under P_2 and page 32, the solution under P_3, have the same format as page 30. With changes in prices, the crops and acreages grown may change. This is accompanied by changes in the resources used, the shadow prices, opportunity cost, etc.

Processing Costs

A record was kept of key punch and computer costs for the six farms used to test the application of the program. The computer processing cost per farm ranged from $4.06 for farm No. 4 to $5.30 for farm No. 6 (see Table 2). The variation is due to the complexity of the matrix generated for the farms and the iterations required for the optimal solutions. The average cost per farm was $4.90 for computer processing and $6.00 for key punch services, to give a total processing cost per farm of $11.90.

Table 2. Key Punch and Computer Cost Per Farm*

Farm	Computer	Key Punch[2]	Total Processing Costs
#1	$5.10	$6.00	$11.10
#2	4.94	6.00	10.94
#3	4.80	6.00	10.80
#4	4.06	6.00	10.06
#5[1]	5.22	6.00	11.22
#6	5.30	6.00	11.30
Average cost	$4.90	$6.00	$10.90

* Oregon State University Computer Center

[1] Processed two reports for this farm; one for the resources the manager now has; the second adding 200 acres more land.

[2] About 1 hour at $6/hr. for key punching and verifying.

Farmers' Reactions

The six test farms had a variety of record systems and sources of input data. The operations were not representative of the typical Willamette Valley farms since three of them had electronic enterprise records and two had been keeping fairly good hand records. An area farm management extension agent was also instrumental in helping three of the farmers with certain input items. This agent used enterprise data sheets and his experience and understanding in helping define enterprise coefficients.

With the use of the Cooperator's Manual, the farmers had no apparent difficulty understanding how to fill in data. This is not to say that problems weren't encountered as all the data wasn't readily available. Information, other than record data, is often required when planning. Examples of this are: 1) When considering an enterprise with which the farmers have had no experience, and 2) In predicting prices that will be received. The farm management agent was helpful in determining the coefficients to use in these cases.

The Computerized Farm Planning Reports were returned to the farm managers without explanation other than the report description in the previously mentioned Cooperators' Manual. This was done to see how well these managers would understand the report without a trained person explaining it to them. Answers on the questionnaires

(Table 1) stated that four of the farmers understood the print-out "fairly well" when they first studied it and two of them understood it "somewhat." (The other choices were "not at all" and "completely".) All six indicated explanation was needed on certain items. "Shadow price" and "opportunity cost" were the two items that needed the most explanation.

When asked what action they would take regarding the suggested solution for their farms, all six indicated they would "implement part of it." Three stated they were going to make some of the suggested organizational changes because they felt these changes would make them more money their present operation. The others indicated several reasons why they wouldn't implement the complete plans suggested in the reports. One indicated a personal dislike for the organization suggested, and another felt the suggested plan for his farm was somewhat impractical because there were not enough land classifications. One farmer was a resident manager that did not own the farm. He liked the suggested plan, but a committee for the owners made organizational decisions for the farm. He felt they might change the operation somewhat because of the report.

The farmers were generally quite receptive to the report and this method of systematized budgeting for farm organization. Many indicated they would like to go through the process in another year including budgets on other crops they would like to consider. This demonstrated to all of them the need for good records and information when planning.

SUMMARY AND CONCLUSIONS

Program Applications

Implementation of changes in farm organization depends upon the goals and personal characteristics of the farm manager as well as the resources at his disposal. While very few farms are completely reorganized, nearly all farms undergo periodic partial reorganization because of changes in the farm's economic and physical environment. This study was designed to test whether linear programming, with the aid of the computer, can be useful in farm planning.

The primary objective in this thesis has been to break down the communication barriers between farmers and the very technical aspects of computers and linear programming jargon so practical application can be made of this mathematical tool. Farmers think in terms of wheat, corn, beans, acres, bushels, hours, dollars, etc. To be effective in education and/or service to farmers, communication needs to be in their terms. Based on the experiences in testing, revising, and developing this program, better understanding of linear programming as a decision making tool for farm managers can be realized when farmer limitations are considered.

The author visualizes various applications of farm organization linear programming. While the resources and contacts of the extension service have been used in developing this system, other organizations or firms could use the program. The system has also been used to a limited degree in the classroom as an aid in teaching farm management and farm organization. Based on an encouraging response, it is felt that effective work could be done using linear programming as a simulation tool in the classroom.

Data Problems

The importance and value of accurate input information cannot be overemphasized. Whether budgeting or planning is done by hand or by the computer, reliable input data is necessary in acquiring meaningful results. Inaccurate data can provide a misleading analysis, which, if followed, could be contrary to the original objective. Caution and good judgment always need to be exercised in gathering input information as the final analysis is no better than the data used.

There are various ways to gather information for a program such as this. Initially in this study, it was felt that general or "canned" data could be used in programming farms. In working with farm operators, it became apparent that canned data was not accurate enough for planning individual operations. Each farm has a different set of resources and resource uses. Each farm manager has different restrictions that he places on his operation and different goals for himself and his family. Because of these individual characteristics, it is difficult to use generalized data in a meaningful way for individual farm planning.

Much of the value derived from working with farmers using linear programming, or any other farm management tool, is the education or insight they receive in the process. The more involved they become in the process of gathering data on their own operation and the better their understanding of how linear programming works, the more likely they are to accept and use the computer solution to their farm planning problem. Involvement is the key in the successful application of this tool. While canned or general information on activities may serve as guidelines, there is a danger of depersonalizing the process to the point where the results are not very meaningful to the farmer.

Farm managers are keeping better records than they have in the past. During the last ten years, many electronic record systems have been developed by universities and private firms. With the use of the computer in record keeping, it is much easier to keep enterprise data separate and to keep details on input requirements for these enterprises. With more detailed information along with an increasing awareness of the importance of management and planning, the environment is right for applying linear programming in farm planning.

Further Research and Development

While the model described here involves crop activities, models including livestock enterprises also have potential for farm planning. Livestock-crop models are often more complex with intermediate products being transferred from one enterprise to another. Livestock activities may consume the production of crop activities and this requires input-output data. Increased model complexity will require more input data and more detailed reports which may reduce the effectiveness of the system through reduced readability of reports.

The shadow price calculations indicate the value of an additional unit of a resource, thus implying a dollar value which management could afford to pay for an additional unit of the resource. This calculation, however, does not provide any information on how many units should be purchased or how many units of the resource can be added before the shadow price changes. A feature called ranging can be added to linear programming algorithms which will indicate how sensitive the shadow prices are or how long they will hold when changing the resource constraints. Inputs like labor, land, and irrigation water are acquired in rather lumpy amounts, not in single units; therefore, it seems logical that this feature would add value to models used for farm planning.

Programmed solutions occasionally include activities at unrealistic levels. An example of this might be a solution suggesting one or two acres of a crop. Because of economies of size, it is intuitively impractical to consider activities at such low levels. Using integer programming (or some type of nonlinear programming), it is possible to avoid this problem.

The crop model described has minimum and maximum acreage constraints that can be used. The integer feature could be added to limit the minimum number of acres of a crop if the crop is to be included in the final solution. For example, barley acreage constraints could be zero for a minimum, 100 for a maximum, and a lower limit of 25 if barley is included in the solution.

This model does not account for the risk and uncertainty relative to the gross margins of the activities. Leonard Bauer has developed a quadratic programming algorithm to be used in farm planning which includes considerations for risk (2). It seems appropriate that Bauer's and other risk and uncertainty models be tested further in a farm application setting. Constraints on various types of labor and machine time could also be tested for their practicality.

Problems encountered when including these programming features or more constraints are the additional complications of the computer program and the computer report and the added computer cost for calculating the solution. It is felt by this author that one of the keys to the successful application of this tool with farm managers is a simple input and output system. While these features appear to add meaning to the programmed solution, they need to be evaluated in terms of their marginal cost and marginal returns (which may be positive or negative).

An addition to the computer report for this crop model does appear to be appropriate at this time. This would be a report using the same format as the programmed solution and would contain data based on the organization of the farm as it exists. The calculations in the report would be based on the existing crops and acreages, and would show a return after variable costs which could be compared to the like calculation in the programmed solution. This would be an indication of the difference in incomes between the farm's present plan and the linear programming plan and provides a test of the accuracy of the data used.

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APPENDIX

FARM MODELING ROUTINE

Program Layout

The initial input is read by the FARMGEN program (FRMGEN binary file). This program both creates and uses the Crop Masters File (Lun 1) and also creates the input for the LP routine. This LP input (LPINP, Lun 2) and the CTL input is used by REX (Version I) to find the optimal solution farm model.[1] (CTL is a control statement indicating the output unit for the LP System.) REX (Version I) in turn creates an LP report (LPRPT, Lun 3) which is read by the FARMRPT program. This generates the final report.

The printout will consist of a report written by each of the three programs. First is a summary report of the original input, generated by FARMGEN. Next is the input for the LP system, also generated by FARMGEN. This is followed by an iteration summary and a rows section and a column section reports. Last is the customer's final report.

The initial input is on file for the teletype under FARMDATA.

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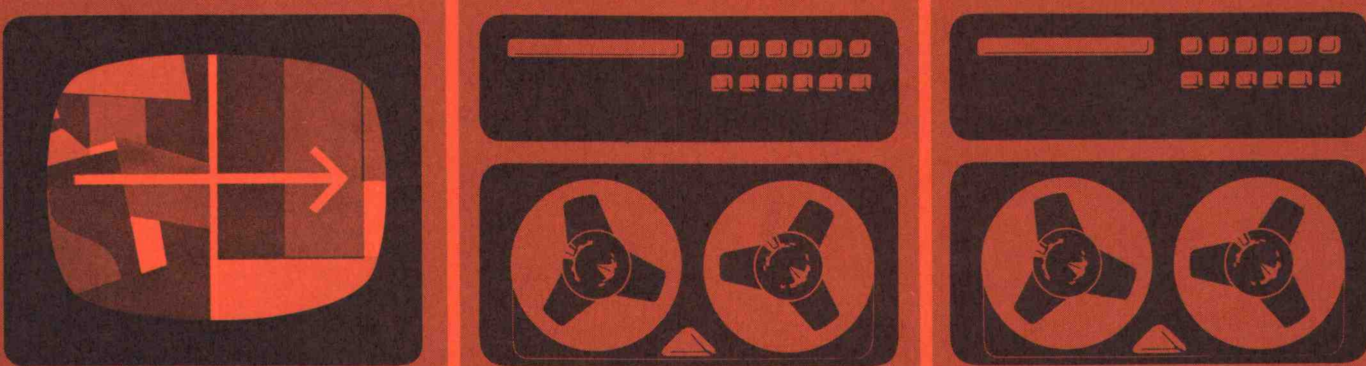
[1] For a detailed description of the linear programming routine, study "REX (Version I), Linear Programming System," Manual 70-16, Oregon State University Computer Center, May 1960, by Lynn Scheurman.

Cooperators Manual

Computerized Farm Planning



Oregon State University

Cooperative Extension Service & Department of Agricultural Economics

COMPUTERIZED FARM PLANNING

Stanley D. Miles 1/

What is Computerized Farm Planning?

Computerized farm planning is a management tool to aid decision making. It is a fast, efficient, and exact budgeting method which can consider at one time many alternative uses of resources (land, labor, capital, etc.). Budgeting has been used for many years for farm planning, but computerized farm planning now makes it feasible to consider many alternative resource combinations and to compare the net income expected from different combinations.

This mathematical technique involves linear or straight line relationships. Constant proportions of inputs are assumed in the production of a crop. For example, if 1 acre of land and $30 of operating capital produce 60 bushels of wheat, then 2 acres of land and $60 of operating capital will produce 120 bushels of wheat.

The technique has been used in many ways since it was developed in the 1940's. It was first used in solving logistic problems by the U. S. Air Force. Most of the major U. S. industries now use it for such things as least cost routing of trains, trucks, and aircraft and the best cuts to make of different size logs given the market and prices for wood products. The technique is used here to determine the best combination of crops and acreages of these crops, for specific farms, which will return the highest net income. To do this a budget needs to be developed for each of the crops considered for the farm. Data on acres of land, hours of labor, dollars of operating capital, etc., also needs to be provided to describe the resource limitations for the farm.

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The Input Forms

Two different input forms are used in collecting information for the program. The first, which will be called the Resources Available form provides data on acres of land, hours of labor, operating capital, etc., for the total farm business. The second, Crop Budget Form, provides data on each crop considered for the farm's organization.

Resources Available: (page 5)

Land--Land may be separated into three different types or productivity levels: Land I, Land II, and Land III. Flood plain or bottom soils would usually be classified as Land I, terrace or bench soils as Land II, and up-land or hill soils as Land III. Although this is the way land is usually classified for the program, any applicable scheme may be used. (Example: Land I as irrigated land, Land II as dry land, and the Land III class left unused.) Fill in the number of acres of each land class that is available for the farm.

Next, enter the use value for each class of land. This value may be defined as the minimum you would be willing to accept for the use of the land. Example: If you can rent out class I land at $30 per acre (after taxes); this is the use value figure for your class I land. Then, if land I doesn't earn at least $30 per acre in the program, it will not be used in the organizational plan.

Operating Capital--The operating capital figure should be the dollars available during the planning year for fertilizer, fuel, feed, seed, etc. (all cash operating expenses that will be required for the crops). Use the maximum amount a lending agency will provide plus any owned operating capital. Next, enter a use value on this capital based on other opportunities for its use or your lender's interest rate. If the lender's rate is 8% and this is the figure entered on the form, the program will not use operating capital if it isn't earning at least 8%.

Labor--Enter the maximum number of hours of labor available each month for productive work directly with the crop enterprises. This should include the hours of the manager's time if he works directly with the crops. Let's say one man will work 160 hours in the month of April. If the manager spends 75 percent of his time working with the crop enterprise and also has a full-time employee who works only with crops, 280 hours (160 hours for the employee plus 120 for the manager) would be entered for the month of April. A use value also needs to be entered for labor. This should be a minimum rate/hour at which labor is willing to perform. If labor doesn't earn at least the rate/hour specified, it will not be used in the program.

Irrigation Water--If irrigation water is available on the farm, enter the maximum number of acre inches available in the months listed. Also enter a use value per acre inch of water based on a cost/acre inch or minimum rate acceptable.

Crop Enterprises Considered--On the botton section of the page, list the crop enterprises to be considered for the farm. After each of these enterprises enter the yield units (lbs., cwt., tons, etc.) and the price per unit expected in the year being planned. Next, fill in the acreage restrictions, minimum, maximum, for each crop. Maximum acreages will probably be used for crops on contract or in a government program. A minimum number of acres may also be specified in the program for crops such as strawberries or caneberries which are already established or for crops on a minimum contract. If there is no minimum or maximum, leave these spaces blank.

Crop Budget Form: (page 6)

A crop budget form is required for each of the crops being considered. At the top of the form, place the name of the crop, the yield expected, the price/unit, and a government payment (acre basis) if one is received. From these figures calculate the gross return/acre. Next, enter the appropriate dollar amount for the items listed as variable costs. Do not include costs for land, operating capital, labor, and irrigation water that are included in the "resources available" form. (The "use values" will make a charge for these inputs.) Add the variable costs, transfer the figure to the right side of the page, and subtract it from gross returns to get the return after variable costs.

Resources used--On the resources used section of this form enter the amounts that will be needed for one acre of the crop. First indicate which class of land is used: 1, 2, or 3. Then, enter the minimum and maximum acreages for the crop being considered. The operating capital figure should include all cash production costs used during the year for one acre of the crop. Enter the number of hours of labor used (to the nearest 10th of an hour) in each month of the year. If irrigation water is used, enter the number of acre inches of water used in the months listed.

With this information the computer program will calculate a cropping plan which will maximize net returns to the restricting resources. So, be realistic and cautious in filling out the forms.

COMPUTERIZED FARM PLANNING

Resources Available

arm Number

Name:

Address:

estricting Resources Available:

Land I : acres, use value: $ /acre

Land II : acres, use value: $ /acre

Land III: acres, use value: $ /acre

Operating Capital: $ Use Value: /$

Labor (Hrs.): Use Value $ /hr.

Jan. Feb. Mar. Apr.

May June July Aug.

Sept. Oct. Nov. Dec.

Water (acre inches) Use value: $ /acre inch

Apr. May June July

Aug. Sept. Oct.--Mar.

rop Enterprises to be considered in the farm organization

Enterprise	Yield Units	Price/ Unit	Minimum Acres	Maximum Acres

COMPUTERIZED FARM PLANNING

Crop Budget Form (per acre basis)

Farm Number: ______________ Crop Name: ______________

Gross Returns: Yield ______ x price ________ + govt. pay. ☐☐☐☐☐ = ________

Variable Costs

Machinery & Equipment $________

Fertilizer ________

Spray & Dust ________

Seeds & Plants ________

Supplies ________

Other Cash Expenses ________

________ ________

Total Variable Costs $________ ☐☐☐☐☐

Gross Return less variable costs ________

Resources Used:

Land Class: ☐ (1, 2, or 3

Acreage limitation on this crop (if any)

Minimum: ______ acres Maximum: ______ acres.

Operating Capital: $ ☐☐☐☐☐☐☐ (for one acre)

Labor in Hours:

Jan. ☐☐☐☐☐ Feb. ☐☐☐☐☐ Mar. ☐☐☐☐☐ Apr. ☐☐☐☐☐

May ☐☐☐☐☐ June ☐☐☐☐☐ July ☐☐☐☐☐ Aug. ☐☐☐☐☐

Sept. ☐☐☐☐☐ Oct. ☐☐☐☐☐ Nov. ☐☐☐☐☐ Dec. ☐☐☐☐☐

Irrigation Water in Acre Inches:

Apr. ☐☐☐☐☐ May ☐☐☐☐☐ June ☐☐☐☐☐ July ☐☐☐☐☐

Aug. ☐☐☐☐☐ Sept. ☐☐☐☐☐ Oct.--Mar. ☐☐☐☐☐

COMPUTERIZED FARM PLANNING REPORT

The report is four pages in length. The first page redefines the resources available on the farm, and the next three pages each offer a suggested solution (crops to be grown) given certain price conditions.

On the first page of the report (page 11) for Ole Nelson Farms, 480 acres of land 2 were available at a $35/acre use value. Since the land on the farm was of fairly uniform quality, land classes 1 and 3 were not used. Nelson also indicated that he could get up to a maximum of $75,000 operating capital with a use value of 10%. Also included are hours of labor available at $1.50/hour and acre inches of water at $1/acre inch.

The enterprises to be considered for Nelson Farms are listed at the bottom of page 11. These may be crops presently being grown and others that would be considered. The acreage restrictions (minimum and maximum) are printed next to the crop identification. Because of participation in the government program, Nelson can't grow more than 250 acres of wheat. Tied to this crop is diverted acres (the last alternative listed), which has a minimum acreage of 65 acres and a maximum of 100. Putting a minimum restriction on an activity forces the program to use at least that number of acres.

The prices used are also listed with the P1 column being the prices normally expected, P2 prices are lower prices, and P3 prices are higher prices. The program calculates a solution for each set of prices.

The production per acre that Nelson expects is printed next along with the gross returns per acre given the three price levels. Gross returns would be the price per unit times the production per acre (plus a government payment if applicable). The last three columns, returns per acre P1, P2, and P3, give a gross margin per acre or a return after the variable costs have been subtracted.

The information on page 11 redefines the resources Nelson indicated were available on the farm and the enterprises to be considered by the program. The next three pages (12, 13, and 14) offer optimum plans for this farm under the three price combinations.

Page 12 of the report is the programmed solution under price level 1 (P1). The resources used, land, operating capital, labor, and irrigation water, are printed under a column headed Used. The resources not needed for the programmed solution are printed in the Unused column. When all of a resource available is used in the solution, the program calculates a shadow price. A shadow price is a value indicating the amount returns would be increased if one more unit of the resource were available. For example, all or 1000 hours of labor available in March were used in the solution and a $5.08 shadow price was computed. Therefore, if one more hour of labor were available in March, returns would increase by $5.08. The shadow prices suggest which resources are limiting on the farm and to what degree they limit the operation.

Next on the page is the programmed solution or the Optimum Enterprise Combination Under Price Level 1. After the crop names are the acreage restrictions for easy reference. The next column (used) gives the acreage of the crops suggested as the optimum solution.

On the Nelson operation, wheat is in the plan at the maximum acreage of 250 acres. Cauliflower is in at about 17½ acres, and so on down the list of crops. Two crops out of the ten considered, chewing fescue and alfalfa, are not in the solution.

The Opportunity Cost column gives a value at which returns/acre would increase if additional acres of the crops listed could be grown. On wheat there is an opportunity cost of $11.09, indicating that if the acreage restriction were increased one acre (to 251), returns would increase by $11.09. The opportunity cost is calculated much like the shadow price but is a value on additional acres in the solution, whereas the shadow price indicates the amount returns would increase if an additional unit of a resource were available.

The opportunity costs for Marion Blackberries and sugar beet seed are quite high. Nelson might consider relaxing the acreage limitations on these crops so that more resources would go into their production. Changing these acreage restrictions may not be realistic. The limitation on Marions might be because of harvest labor available, and Nelson may not be able to get a contract for more than 15 acres of sugar beet seed.

The total return column is calculated by multiplying the acreages in the solution times the returns per acre. For wheat there are 250 acres. Multiplying this times $66.90 per acre gives $16,725. The addition of this column gives a total return (after variable costs) to the programmed solution for the farm of $68,318.44. The table in the lower left of the page gives the total value of restricting resources used of $34,138.76. This is calculated by multiplying the units of resources used times the use value. Four hundred eighty acres of land 2 were used in the solution. At $35 per acre, there is a charge of $16,800. Subtracting the total value of restricting resources used from the return after variable costs gives $34,179.68. From this, fixed and overhead costs which have not been accounted for, may be subtracted to give a return to management. This return to management is a return to crops in the programmed solution given the costs and returns reported on the crop budget forms.

The next two pages, 13 and 14, have the same format as page 12. With changes in prices, the crops and acreages grown may change. This is accompanied by changes in the resources used, the shadow prices, opportunity cost, etc. When going from average prices to low prices in the Ole Nelson operation, the program does not include the 87 acres of crimson clover and leaves the land unused. In fact, the opportunity cost for growing crimson clover with lower prices (page 13) is -$12.71. This means that if an acre of crimson clover were forced in under these price conditions, returns would be reduced by $12.71.

This report can be used by manager Nelson as a tool in making farm organization decisions. He can compare the crops suggested by the program with his present operation for changes that might be made to improve his income. If Nelson finds that he had an error on the input forms, a correction can be made and the program processed a second time. Other changes, such as adding more land, labor, or a new crop, can be made to see what effect they will have on the cropping plan and the income received. The program is designed as a tool for the farm managers to use in deciding which crop to grow and should not be interpreted as the "final solution."

*** R E S T R I C T I N G R E S O U R C E S A V A I L A B L E ***

LAND 1	0 ACRES	LAND 2	480 ACRES	LAND 3	0 ACRES	OPERATING CAPITAL	75000
$	0/ACRE	$	35/ACRE	$	0/ACRE	OPERATING CAPITAL AT 10%	

HOURS OF LABOR
COST $ 1.50/HR.

JANUARY	450	FEBRUARY	1000	MARCH	1000	APRIL	1000	MAY	1500	JUNE	2450
JULY	2000	AUGUST	2000	SEPTEMBER	1000	OCTOBER	1000	NOVEMBER	450	DECEMBER	450

ACRE-INCHES OF WATER FOR IRRIGATION
PRICE $ 1.00/ACRE-INCH

APRIL	300	MAY	300	JUNE	300	JULY	300	AUGUST	300	SEPTEMBER	300

OCTOBER THRU MARCH 300

*** E N T E R P R I S E S T O B E C O N S I D E R E D ***

CROP ALTERNATIVES	ACREAGE MIN.	ACREAGE MAX.	PRICE PER UNIT P1	PRICE PER UNIT P2	PRICE PER UNIT P3	PRODUCTION PER ACRE	GROSS RETURN PER ACRE P1	GROSS RETURN PER ACRE P2	GROSS RETURN PER ACRE P3	RETURN PER ACRE P1	RETURN PER ACRE P2	RETURN PER ACRE P3
WHEAT	0	250	45.00	42.50	47.50	2.0 TON	90.00	85.00	95.00	66.90	61.90	71.90
CAULIFLOWER	0	35	130.00	104.00	156.00	4.0 TON	520.00	416.00	624.00	358.70	254.70	462.70
STRAWBERRIES	14	35	.17	.15	.19	9000.0 LBS	1530.00	1350.00	1710.00	769.60	589.60	949.60
FESCUE CHEWINGS	0	150	.18	.14	.22	400.0 LBS	72.00	56.00	88.00	48.35	32.35	64.35
BLACKBERRIES MA	5	10	.14	.12	.16	10000.0 LBS	1400.00	1200.00	1600.00	676.20	476.20	876.20
BLACKBERRIES EV	0	10	.14	.12	.16	10000.0 LBS	1400.00	1200.00	1600.00	660.00	460.00	860.00
SUGAR BEET SEED	0	15	.20	.17	.23	2000.0 LBS	400.00	340.00	460.00	326.20	266.20	386.20
ALFALFA	0	30	25.00	21.60	28.40	5.0 TON	125.00	108.00	142.00	76.00	59.00	93.00
CLOVER CRIMSON	0	100	.19	.15	.23	500.0 LBS	95.00	75.00	115.00	58.00	38.00	78.00
DIVERTED ACRES	65	100	40.00	40.00	40.00	1.0 ACRE	40.00	40.00	40.00	35.00	35.00	35.00

*** USE OF RESTRICTING RESOURCES UNDER PRICE LEVEL 1 ***

RESOURCE	USED	UNUSED	SHADOW PRICE	RESOURCE	USED	UNUSED	SHADOW PRICE
LAND 1	0	0	-0				
LAND 2	480.00	0	5.18	OPERATING CAPITAL	25280.99	49719.01	-0
LAND 3	0	0	-0				
HOURS OF LABOR				HOURS OF LABOR			
JANUARY	110.40	339.60	-0	JULY	1152.78	847.22	-0
FEBRUARY	780.00	220.00	0	AUGUST	1024.61	975.39	-0
MARCH	1000.00	0	5.08	SEPTEMBER	657.84	342.16	-0
APRIL	711.82	288.18	-0	OCTOBER	1000.00	0	4.45
MAY	302.54	1197.46	-0	NOVEMBER	88.08	361.92	-0
JUNE	2450.00	0	6.37	DECEMBER	0	450.00	-0
ACRE-INCHES OF WATER				ACRE-INCHES OF WATER			
APRIL	0	300.00	0	JULY	227.96	72.04	0
MAY	103.96	196.04	-0	AUGUST	207.96	92.04	0
JUNE	197.71	102.29	-0	SEPTEMBER	155.96	144.04	-0
				OCT.-MAR.	0	300.00	0

*** OPTIMUM ENTERPRISE COMBINATION UNDER PRICE LEVEL 1 ***

ENTERPRISE	ACREAGE MIN.	ACREAGE MAX.	ACREAGE USED	OPPORTUNITY COST	RETURN PER ACRE	RETURN TOTAL
WHEAT	0	250	250.00	11.09	66.90	16725.00
CAULIFLOWER	0	35	17.62	-0	358.70	6318.82
STRAWBERRIES	14	35	26.98	-0	769.60	20764.25
FESCUE CHEWINGS	0	150	0	-3.24	48.35	0
BLACKBERRIES MA	5	10	10.00	180.07	676.20	6762.00
BLACKBERRIES EV	0	10	8.38	-0	660.00	5533.21
SUGAR BEET SEED	0	15	15.00	202.77	326.20	4893.00
ALFALFA	0	30	0	-2.60	76.00	0
CLOVER CRIMSON	0	100	87.02	-0	58.00	5047.15
DIVERTED ACRES	65	100	65.00	-16.30	35.00	2275.00

RETURN (AFTER VARIABLE COSTS) $ 68318.44

RESOURCES	USED	USE VALUE	COST
LAND 2	480.00	35.00	16800.00
OP. CAP.	25280.99	.10	2528.10
LABOR	9278.08	1.50	13917.11
WATER	893.55	1.00	893.55

TOTAL VALUE OF RESTRICTING RESOURCES USED $ 34138.76 — 34138.76

DIFFERENCE $ 34179.68

OVERHEAD COSTS ---------

RETURN TO MANAGEMENT

*** USE OF RESTRICTING RESOURCES UNDER PRICE LEVEL 2 ***

RESOURCE	USED	UNUSED	SHADOW PRICE
LAND 1	0	0	-0
LAND 2	394.02	85.98	-0
LAND 3	0	0	-0
HOURS OF LABOR			
JANUARY	23.37	426.63	-0
FEBRUARY	780.00	220.00	-0
MARCH	1000.00	0	2.04
APRIL	717.18	282.82	-0
MAY	310.07	1189.93	-0
JUNE	2450.00	0	4.26
ACRE-INCHES OF WATER			
APRIL	0	300.00	0
MAY	106.14	193.86	-0
JUNE	200.94	99.06	-0

RESOURCE	USED	UNUSED	SHADOW PRICE
OPERATING CAPITAL	22826.31	52173.69	-0
HOURS OF LABOR			
JULY	1119.49	880.51	-0
AUGUST	942.73	1057.27	-0
SEPTEMBER	485.75	514.25	-0
OCTOBER	1000.00	0	2.03
NOVEMBER	87.95	362.05	-0
DECEMBER	0	450.00	-0
ACRE-INCHES OF WATER			
JULY	229.96	70.04	-0
AUGUST	209.96	90.04	-0
SEPTEMBER	158.05	141.95	-0
OCT.-MAR.	0	300.00	0

*** OPTIMUM ENTERPRISE COMBINATION UNDER PRICE LEVEL 2 ***

ENTERPRISE	ACREAGE MIN.	ACREAGE MAX.	ACREAGE USED	OPPORTUNITY COST	RETURN PER ACRE	RETURN TOTAL
WHEAT	0	250	250.00	15.20	61.90	15475.00
CAULIFLOWER	0	35	17.59	-0	254.70	4479.95
STRAWBERRIES	14	35	28.07	-0	589.60	16549.95
FESCUE CHEWINGS	0	150	0	-12.86	32.35	0
BLACKBERRIES MA	5	10	10.00	89.16	476.20	4762.00
BLACKBERRIES EV	0	10	8.37	0	460.00	3848.13
SUGAR BEET SEED	0	15	15.00	161.27	266.20	3993.00
ALFALFA	0	30	0	-8.07	59.00	0
CLOVER CRIMSON	0	100	0	-12.71	38.00	0
DIVERTED ACRES	65	100	65.00	-9.01	35.00	2275.00

RETURN (AFTER VARIABLE COSTS) $ 51383.03

RESOURCES	USED	USE VALUE	COST
LAND 2	394.02	35.00	13790.85
OP. CAP.	22826.31	.10	2282.63
LABOR	8916.52	1.50	13374.79
WATER	905.04	1.00	905.04

TOTAL VALUE OF RESTRICTING RESOURCES USED $ 30353.32   30353.32

DIFFERENCE $ 21029.71

OVERHEAD COSTS ---------

RETURN TO MANAGEMENT

*** USE OF RESTRICTING RESOURCES UNDER PRICE LEVEL 3 ***

RESOURCE	USED	UNUSED	SHADOW PRICE
LAND 1	0	0	-0
LAND 2	480.00	0	17.56
LAND 3	0	0	-0
HOURS OF LABOR			
JANUARY	123.50	326.50	-0
FEBRUARY	786.63	213.37	-0
MARCH	1000.00	0	8.00
APRIL	704.89	295.11	-0
MAY	301.93	1198.07	-0
JUNE	2450.00	0	8.40
ACRE-INCHES OF WATER			
APRIL	0	300.00	0
MAY	103.61	196.39	-0
JUNE	197.42	102.58	-0

RESOURCE	USED	UNUSED	SHADOW PRICE
OPERATING CAPITAL	25363.43	49636.57	-0
HOURS OF LABOR			
JULY	1165.43	834.57	-0
AUGUST	1026.04	973.96	-0
SEPTEMBER	671.78	328.22	-0
OCTOBER	1000.00	0	6.69
NOVEMBER	89.74	360.26	-0
DECEMBER	0	450.00	-0
ACRE-INCHES OF WATER			
JULY	229.40	70.60	-0
AUGUST	209.40	90.60	-0
SEPTEMBER	156.51	143.49	-0
OCT.-MAR.	0	300.00	0

*** OPTIMUM ENTERPRISE COMBINATION UNDER PRICE LEVEL 3 ***

ENTERPRISE	ACREAGE MIN.	ACREAGE MAX.	ACREAGE USED	OPPORTUNITY COST	RETURN PER ACRE	RETURN TOTAL
WHEAT	0	250	236.75	0	71.90	17022.12
CAULIFLOWER	0	35	17.95	0	462.70	8304.87
STRAWBERRIES	14	35	26.81	-0	949.60	25456.00
FESCUE CHEWINGS	0	150	0	-0.75	64.35	0
BLACKBERRIES MA	5	10	10.00	267.68	876.20	8762.00
BLACKBERRIES EV	0	10	8.50	-0	860.00	7307.41
SUGAR BEET SEED	0	15	15.00	237.56	386.20	5793.00
ALFALFA	0	30	0	-4.08	93.00	0
CLOVER CRIMSON	0	100	100.00	5.58	78.00	7800.00
DIVERTED ACRES	65	100	65.00	-30.72	35.00	2275.00

RETURN (AFTER VARIABLE COSTS) $ 82720.41

RESOURCES	USED	USE VALUE	COST
LAND 2	480.00	35.00	16800.00
OP. CAP.	25363.43	.10	2536.34
LABOR	9319.94	1.50	13979.91
WATER	896.33	1.00	896.33

TOTAL VALUE OF RESTRICTING RESOURCES USED $ 34212.58 — 34212.58

DIFFERENCE	$ 48507.83
OVERHEAD COSTS	---------
RETURN TO MANAGEMENT	