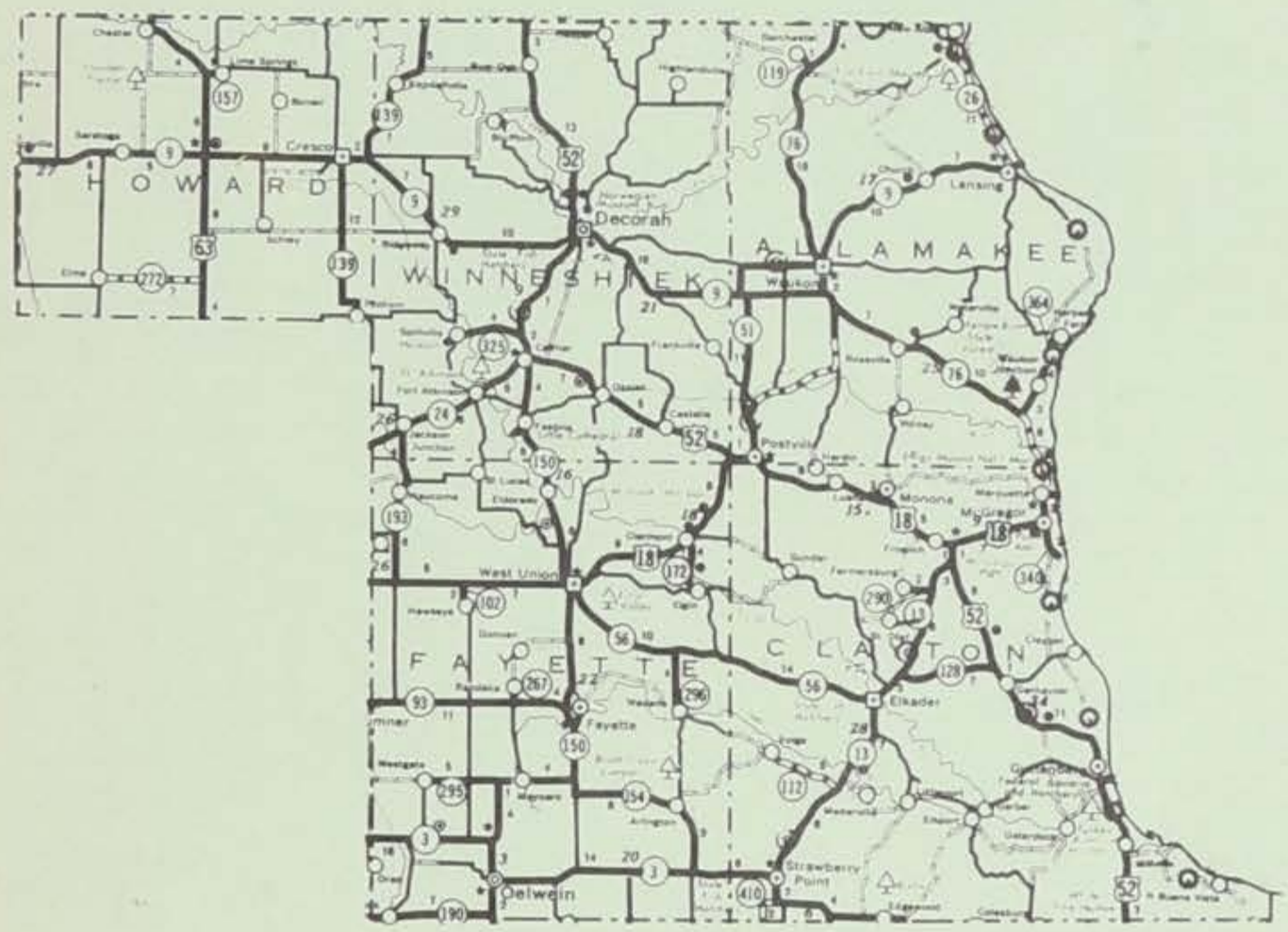
DEVELOPMENT AND APPLICATION OF A MODEL FOR MULTI-COUNTY RURAL COMMUNITY DEVELOPMENT



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THE CENTER FOR
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DEVELOPMENT AND APPLICATION OF A MODEL FOR MULTI-COUNTY RURAL COMMUNITY DEVELOPMENT

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INTRODUCTION

American society has become concerned with the problems of rural areas. These problems result from advances in agricultural technology requiring fewer farm workers and the concentration of national economic growth at urban centers. This concern is being reflected in numerous programs at both state and national levels designed to examine and implement positive income and employment possibilities in rural communities. The study reported here is of this nature. It applies to the five-county Upper Explorerland of northeast Iowa and has been made both for the quantitative answers it provides and for testing of a method in analysis of rural area development. While a specific area of Iowa is used for the quantitative application, the model developed should have general adaptation for the economic planning of other rural areas.

Study Area and Project Genesis

This study includes the counties of Allamakee, Clayton, Fayette, Howard, and Winneshiek. A group of citizens in this five-county area met monthly for a period of over a year in 1970-71 with the purpose of aggregating data and resources to affect an area development effort. An organization with a central executive committee consisting of several persons from each of the five counties was established. The group's long-term goal was to bring about an area development program to eliminate the disparities in employment, income, housing, and other concerns which characterize the five-county area. A shorter-term goal was to make application to, and obtain approval of, one of the several federal assistance programs which were available to rural areas.

Upon organization of the Center for Agricultural and Rural Development (CARD) a preliminary inquiry was made by the chairman of the Upper Explorerland executive committee to CARD to determine if the two organizations possessed mutual goals and interest. It was determined after several subsequent meetings that there was mutual interest and that an informal relationship between the two organizations could benefit both.

This relationship was approved by both parties and by the

Agricultural Experiment Station of Iowa State University in late fall of 1971. The five-county area was to receive (a) assistance in locating and summarizing data relevant to their developmental efforts and (b) several solutions to a rural community development model to be built and applied to their area. CARD was to benefit by (a) the use of the five counties as a pilot study area on which to test the rural community development model and (b) the assistance of local persons and organizations in developing the necessary informational base on which to build the model.

In September 1971 the five-county area was approved by the U.S. Department of Agriculture as a Resource Conservation and Development Project (RC&D) administered by the Soil Conservation Service. Under the title of "Upper Explorerland RC&D Project," the area was provided a project coordinator for the developmental effort.

The location of the five-county area is indicated in Fig. 1. The rural nature of the Upper Explorerland area is evident in the information presented in Tables 1-6. The area had a total 1970 population of 95,672[1] people and total employment of 34,576 workers. Of these, 9,651 (over 27 percent) were employed directly in production agriculture.

Total population has been decreasing at a rate of about 0.5 percent per year. Persons of the productive ages (20-44 years of age) have been declining both in absolute number and in percentage of total population. The age group 20-46 years contained only 65 percent as many persons in 1970 as in 1940. In 1970, the number of persons 65 years of age and over was 133 percent of the number in 1940. A significant decrease also has taken place over the last decade in the number of persons under 5 years of age.

Only 40.5 percent of the residents lived in towns of over 1,000 population. Another 12.3 percent lived in towns of less than 1,000 population, and 47.2 percent lived on farms in 1970. The largest town in the five-county area had a 1970 population of 7,735. Average annual family incomes of each of the five counties ranged from $6,267 to $7,585, compared to the state

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[1]All data is based on the 1970 Census of Population [25].

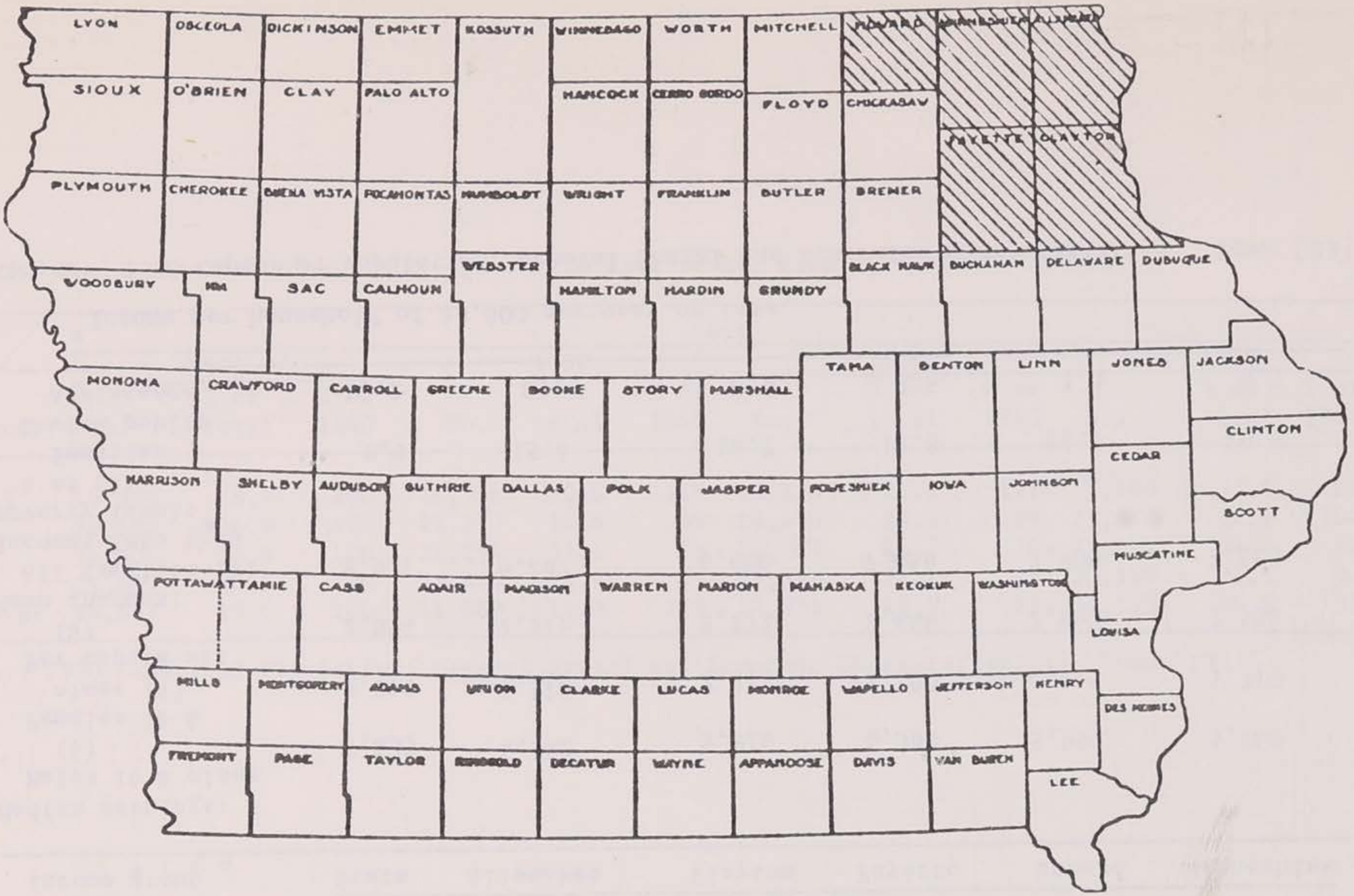

Fig. 1. Location of Upper Explorerland RC&D Project area.

Table 1. Selected economic characteristics of 1970 population of the five-county area.

Age and income group	State	County				
		Allamakee	Clayton	Fayette	Howard	Winneshiek
Median earnings:						
Males 16 & older ($)	7,839	4,942	5,916	6,380	5,992	5,740
Females 16 & older ($)	3,019	2,120	2,211	2,190	2,215	1,719
Per capita all ($)	2,894	2,315	2,272	2,446	2,662	2,538
Mean incomes:						
All families ($)	8,931	6,267	6,604	7,459	7,909	7,585
Incomes less than poverty level:[a]						
% of all families	8.9	15.6	14.7	12.8	16.5	10.5
% with public assistance	13.2	8.1	6.9	8.5	3.3	9.3

[a] Income per household of $3,000 per year or less.

Source: 1970 Census of Population, General Social and Economics Characteristics: Iowa [23].

Table 2. Population distribution by age of the five-county area by indicated years.

	Year											
	1940			1950			1960			1970		
Age group	No.	% of total	% of 1940	No.	% of total	% of 1940	No.	% of total	% of 1940	No.	% of total	% of 1940
Under 5	9,303	8.7	100	10,958	10.8	118	11,275	11.2	121	7,509	7.8	81
5-19	28,592	26.9	100	25,317	24.8	89	28,416	28.2	99	29,802	31.2	104
20-44	36,504	34.3	100	32,254	31.6	88	26,907	26.7	74	23,624	24.7	65
45-64	21,857	20.5	100	21,819	21.4	99	21,318	21.1	98	20,594	21.5	94
65 & over	10,657	10.0	100	11,563	11.3	109	12,991	12.9	122	14,135	14.8	133

Source: 1970 Census of Population, General Social and Economic Characteristics: Iowa [23].

Table 3. Employment by occupation in the five-county area.

Occupational group	Year			
	1940	1950	1960	1970
Professional, technical	2,173	2,234	2,706	3,054
Farmers and farm managers	12,779	12,184	10,608	7,478
Proprietors	2,794	2,853	2,433	2,687
Clerical	2,797[a]	1,973	2,751	3,743
Sales	--[a]	1,965	2,677	1,801
Craftsmen	2,249	3,137	3,167	3,495
Operatives	2,168	2,929	3,685	4,363
Private household	1,102	459	618	629
Service	1,338	1,839	2,428	3,886
Farm laborers	3,511	2,311	4,195	2,173
Other laborers	1,352	1,631	1,293	1,267
Not reported	297	653	612	--
Total employment	35,518	38,110	37,173	34,576

[a]The clerical group includes sales for 1940.

Source: 1970 Census of Population, General Social and Economic Characteristics: Iowa [23].

Table 4. Employment by sex for the five-county area.

Item	Year			
	1940	1950	1960	1970
Total population	106,463	101,911	100,898	95,672
Total employment	35,518	38,130	37,343	34,576
% of persons employed	33	37	37	36
Males in work force[a]	40,525	37,406	34,425	33,169
Males employed	30,485	30,084	26,826	23,055
% of males employed	75.2	80.5	77.9	69.5
Females in work force[a]	40,128	35,655	34,745	34,865
Females employed	5,033	8,046	10,515	11,521
% of females employed	12.5	22.6	30.3	33.0
% total employment males	86	79	72	67
% total employment females	14	21	28	33

[a]19 years of age and older.

Source: 1950 Census of Population, General Social and Economic Characteristics: Iowa [23].

Table 5. Educational attainment of population over 25 years of age in the five-county area.

Years in school		Year 1940	1950	1960	1970
Total number		60,538	59,050	56,169	52,647
No school		329	280	230	260
Grade school,	1-4	2,907	2,725	1,833	1,089
	5-6	6,633	4,700	3,275	4,034
	7-8	29,521	25,573	21,577	14,274
High school	1-3	7,149	7,250	6,936	6,744
	4	8,569	11,115	14,863	18,710
College	1-3	3,087	4,175	4,792	4,603
	4 or more	1,860	2,030	2,573	2,955

Source: Census of Population for specific years [21].

Table 6. Selected agricultural statistics for the five-county area.

Farm item	Year 1940	1950	1959	1964	1969
No. of farms	12,803	12,185	10,833	9,825	8,868
Average farm size (acres)	156.0	164.6	181.9	200.4	216.8
% tenancy	40.6	32.3	27.4	21.7	15.1
Value farm products sold (000$)	-- [a]	73,562	104,657	111,521	170,491

[a]Not available for 1940.

Source: Census of Agriculture, USDA, for specific years [20].

average of $8,931 in 1970.

PROGRAMMING MODEL AND RESEARCH OBJECTIVES

This study was conducted in a five-county area of northeast Iowa as a pilot investigation. One of its major purposes was to develop and test the application of a mathematical model to the problems and multi-goal objectives of rural community development. The model developed can have applicability to other geographic areas similarly dominated by agriculture and a rural environment. A major portion of this report explains methods used in developing resource data, defining production and consumption activities, and in analysis of information provided by solutions of the model. It is hoped that this background will be useful and applicable in other developmental project areas.

Several research workers have used mathematical models for problems associated with rural community development. Most models provide either single-sector analysis (i.e., consider only agricultural or industrial activities as variables in the solution) or have single-goal orientation (i.e., consider an increase in per capita income as the only dependent variable). The mathematical programming model used in this study considers (a) the physical and human resources as the only restraining factors, (b) allows for changes in all economic sectors, and (c) provides the attainment of the multiple goals related to rural community development. Specifically, the purpose of the research was to build a linear programming model which can:

(1) Use information from published sources to enumerate and quantify resources and to define productive and consumptive activities.

(2) Have the capability of analyzing the entire economy of a multi-county area.

(3) Provide for achievement of certain and multiple goals necessary for rural community development.

(4) Provide planners and others with information

important to their decision-making process to enable them to better carry out their responsibilities in regard to rural community development.

Objective Function and Time Periods

The objective function is a central element of a linear programming model and the types of answers or problem solutions sought from it. Solutions are determined regarding resource allocations within the model on the basis of maximizing or minimizing an objective function or specified goal. This goal or objective function is optimized relative to restraints in resources and minimum or maximum objectives to be attained. Numerous objective function choices are possible for rural community development. These include maximizing gross or net income, maximizing value of exports from an area, minimizing costs of welfare, minimizing outside investments, maximizing employment, and others.

The objective function of this model maximizes additions to investment capital subject to certain economic-social goals or conditions to be attained in the five-county Upper Explorerland area. Such variable activities as land drainage or permanent conservation practices, increased industrial capacity, improved labor productivity through education, and public investments in roads and other facilities provide additions to investment capital. Each of these variables thus has a weight in the objective function. Only one restriction is placed on these additions to investment capital. This restriction requires that the investment provide profitable utilization of resources. For example, land is not allowed to be drained unless the resulting increased productivity covers the amortized cost of the land drainage activity.

Rural community development is a process. This development process implies and requires a dynamic model capable of analyzing resource use and activity levels at several points in the relevant time span. Thus, changes in the resource base affected by activities in one time period can be considered in all subsequent

time periods. A three-period model is used in this study. Each period is three years in length. This total time span approximates the "apparently" most popular developmental planning horizon of ten years. Appropriate transfers are provided between time periods to allow for simultaneous solution of the dynamic model. A complete representation of the model is presented in a later section.

Information Provided by Solutions

The linear programming solutions provide six types of information of interest to community and regional planners. Included are: (a) solution values, (b) resource use analysis, (c) shadow price analysis, (d) reduced cost analysis, (e) range analysis, and (f) trancol analysis.

Solutions

The solution to a linear programming model indicates the specific activities and the absolute level of each activity to satisfy the restraints and maximize (or minimize) the objective function. For this study a solution is provided for each of the three time periods.

A second aspect of the solution is the specification of the amount of each resource used and the amounts in disuse. Again, in this study, information is provided for each time period.

Shadow prices of limiting resources

Resources used at a nonrestricting level have a marginal value product equal to zero. Hence, they are of no particular interest. However, resources used at a restrictive level (at the upper limit of availability) have a value of marginal product at some value greater than zero and are of possible interest to planners. The linear programming model specifies which resources are consumed at the upper limit and further calculates the value of marginal product associated with each.

This analysis indicates the specific value to the objective function of one additional unit of each restrictive resource. This type of information can be valuable in making decisions regarding the use of these particular resources.[2]

Reduced costs of increased activity levels

Closely associated with the shadow prices of limiting resources discussed above is information provided regarding increased levels of activities in excess of the amounts denoted in the model solution. As discussed above, these solution levels are selected to most efficiently maximize the objective function. Any deviation from these solution levels must result in a decrease in the value of the objective function. The information, denoted as "reduced costs," indicates the amount of decrease in objective function associated with "forcing into the solution" one additional unit of a specific activity holding resource levels constant.[3]

Range analysis

The range analysis provides an extension of the "shadow price" or "reduced cost" information. In general it denotes the range of resource availability over which the "shadow price" value is relevant. Likewise, range analysis indicates the range of activity levels over which the "reduced cost" value is relevant.

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[2]For example, if the solution indicates that 100 units of labor are being used, and the total amount available was also 100 units, the "shadow price" analysis indicates the amount of the increase in objective function if one additional unit was made available, raising the total available to 101 units.

[3]For example, if the solution indicates the level of industry A to be 100 units, the "reduced cost" analysis indicates the extent of the decrease in objective function value associated with one additional unit or 101 units of industry A.

Trancol analysis

The trancol analysis, a recent addition to linear programming, indicates the disposition of an additional unit of resource among the various activities. This analysis accompanied by the "shadow price" value and the range analysis has promise of providing much information related to efficient resource use.

Each of the above six types of information is measured and discussed in this study. Particular attention is given to the relevance and usage of the information in rural community development.

RESOURCES IN THE AREA

Defining and enumerating the resource base of the area is a necessary phase in developmental planning. This phase is accomplished in two steps. First, basic resource categories must be identified for which data is available or can be gathered. A further consideration is to select resource categories which will allow a meaningful analysis. The second step involves an enumeration of the resources in each of the selected categories.

Since the Nineteenth Century, economists have classified economic resources into three groups: land, labor, and capital. In this study the same basic classification is used. Data is available, although not always in the forms desirable, to analyze a regional economy using the basic resource classification.

Each of the three basic resources are discussed in the following sections. Emphasis is placed on the methods used to prepare the available data for use in the linear programming model.

Land

The land resource was classified with a two-way system. A basic inventory utilized was the "Land Use Capability Classification" as delineated in the Iowa Conservation Needs Inventory [28]. This classification system is the most consistent system of those in popular usage, particularly for the purpose of this study, due to its emphasis on use capability.[4] Column 1 of Table 7 indicates the total acreage included in each of the land use capability classes for the five-county area of the study.

Two further classifications are made in the Iowa Conservation Needs Inventory [28]. They provide information on (a) current usage of the land resource and (b) dominant limitations which the

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[4] See Iowa Conservation Needs Inventory [28] for a complete description of each land use capability class.

Table 7. Land resource acres by use capability class.

Land use class	Column 1 Total	2 A	3 B	4 C	5 D	6 E	7 F	8 G
I	98,733	58,081	12,576	855	20,177	0	7,044	0
II	680,265	205,346	96,806	305,533	55,470	0	17,110	0
III	625,857	121,211	527	378,914	68,181	0	57,024	0
IV	198,288	27,356	0	92,924	17,483	17,483	43,042	0
V	27,616	0	0	0	0	19,200	8,416	0
VI	101,852	0	0	0	0	50,408	29,159	22,285
VII	251,605	0	0	0	0	39,250	195,072	17,283
Totals	1,984,216	411,994	109,909	778,226	161,311	126,341	356,867	39,568

Source: Iowa Conservation Needs Inventory 1970 [28].

various soil groups possess.[5] In extensive discussion with Soil Conservation Service personnel, an annual soil loss of four tons per acre was agreed upon as being the maximum allowable to maintain the soil resources of the area.

These three considerations, (a) current land usage, (b) dominant limitations, and (c) maximum soil loss, were aggregated to develop allowable cropping systems which link current usage of the land to future possibilities. This system is described below, and the relevant acreage is given in columns 2 through 8 of Table 7.

Crop Pattern A--Cropland needing no investment and capable of intensive cropping.

Crop Pattern B--Cropland needing investment in drainage.

Crop Pattern C--Cropland needing investment in conservation measures.

Crop Pattern D--Permanent pasture which can be renovated or converted to cropland.

Crop Pattern E--Permanent pasture which can be renovated and cropland to be seeded to pasture.

Crop Pattern F--Forest land which in some cases can be cleared for cropland.

Crop Pattern G--Cropland or pasture which will be converted to forest land.

For this study, the following assumptions are made in regard to future land use potential:

(1) All capability Class I land can be intensively cropped. That currently in permanent pasture or forested can be converted to cropland.

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[5]These are (a) susceptibility to erosion, (b) excess water, and (c) limitations in the root zone.

(2) Classes II, III, and IV land can be cropped with decreasing intensity.

(a) Class II land can be cropped at a ratio of two years row crop to one year cover crop. All land currently in permanent pasture or forested can be converted to cropland.

(b) Class III land can be cropped at a ratio of two years row crop to two years cover crop. All land currently in permanent pasture can be converted to cropland, and land currently forested will remain such.

(c) Class IV land can be cropped at a ratio of one year row crop to two years cover crop. One-half of the land currently in permanent pasture can be converted to cropland, and land currently forested will remain such.

(3) Classes V, VI, and VII are not suited for cropland. Pasture, forest, or recreation usage is permitted.

(a) All of Class V land currently in crops will be converted to pasture.

(b) One-half of Class VI land currently in crops will be converted to pasture and the balance to forest.

(c) Three-fourths of Class VII land currently in crops will be converted to forest and the balance to pasture.

Activities were defined to clear land of trees, provide drainage, construct conservation structures, reforest land, seed pasture, renovate pasture, and convert pasture land to cropland. These activities move land from one capability category to another consistent with the restrictions outlined above. For example, an activity was defined to convert land from Class I-F to Class I-A by the clear-cutting of trees. These activities are discussed in detail in a following section. They did not, however, include objective function weights relating to scenic

and asthetic values of the landscape. In further studies, these weights might be obtained through various means such as Delphi surveys of community leaders or tourists.

Labor

The Census of Population classified the labor force of counties by two systems. In the volume General Social and Economic Characteristics: Iowa [25] (Table 122), the labor force is delineated by occupation. Twelve major occupational categories are reported. Section A of Table 8 summarizes data for this inventory for the five counties of the study. The data shown include those working and those unemployed at the time of the census. The same Census of Population volume (Table 123) enumerates the work force by forty industry classes. For ease of model building, these industry classes were aggregated into 12 classes and finally reduced to 11 because the mining class for the areas had less than 100 workers. Section B of Table 8 summarizes this data for the five counties. The total labor force in Section B does not include the 1,154 workers unemployed at the time of the census enumeration.

A further division of the labor force by education was deemed important in the model. While census data are available for educational attainment of people over 25 years of age, comparative data are not available to indicate the educational background, by either occupation or industry, of groups of workers. The following assumptions were made on the educational requirements of workers in the various occupations:

(1) Occupations requiring four years or more advanced education include professional-technical.

(2) Occupations requiring two years of advanced education include managers and administrators, clerical, craftsmen, operatives, farmers and farm managers, and service workers.

(3) Occupations requiring a high school degree include sales workers, transport, laborers, farm laborers, and private household workers.

Table 8. Labor force by occupations and industry in the area.

Occupation	No. workers
Section A--Labor force by occupations[a]	
Professional, technical, and kindred workers	3,054
Managers and administrators, except farm	2,729
Sales workers	1,850
Clerical and kindred workers	3,874
Craftsmen, foremen, and kindred workers	3,704
Operatives, except tranport	3,314
Transport equipment operatives	1,464
Laborers, except farm	1,309
Farmers and farm managers	7,478
Farm laborers and farm foremen	2,238
Service workers, except private household	3,990
Private household workers	665
Total labor force by occupations	35,730[b]
Section B--Labor force by industry[c]	
Agriculture, forestry, and fisheries	9,871
Mining[d]	93
Construction	1,826
Manufacturing	3,790
Transportation[e]	1,752
Trade	7,130
Finance, real estate, and insurance[e]	841
Business and repair services	610
Personal services[e]	1,515
Entertainment and recreation services	111
Professional services[e]	6,092
Public administration	945
Total labor force by industry	34,576

[a]Data from table 122, 1970 Census of Population, General Social and Economic Characteristics [23].

[b]Includes 1,154 unemployed workers.

[c]Data taken from table 123, 1970 Census of Population, General Social and Economic Characteristics [23].

[d]Mining was eliminated in the model due to the low numbers of persons employed.

[e]Some aggregation of census data was accomplished to ease model building.

A chart was designed to allocate workers of the specific occupations to the various industry classifications. Table 9 indicates the occupations employed by industry groups, using the complete classification system in the census plus the description of types of work done by the various occupational classes.[6] For example, the "transportation" industry employs managers and administrators, clerical workers, transport workers, and laborers. Table 10 indicates an input table to allocate workers by occupation to the various industry groups. The allocation was accomplished using a proportioning method, census classifications, and judgment on the part of the researchers. Each column of Table 10 totals 1.0 and is used in the following manner: Each worker employed in an industry class is considered to be a composite of the various occupations indicated in the table. For example, each person employed in the "transportation" industry is allocated as:

0.1315	manager and administrator
0.1836	clerical worker
0.6000	transport worker
0.0849	laborer
1.0000	total

The occupational classes are thus allocated to the various industry classes.

The census indicates a total of 35,730 members of the labor force. A total population of 95,672 persons was residing in the five-county area in 1970. By simple division, each member of the labor force must support 2.677 persons on the average.

Activities were defined within the model to transfer workers among occupations. In some instances, the persons transferred required two or four years of post high school education. These educational activities, described in detail in a later section, were considered to be a capital investment and therefore added to the increase in the objective function. As mentioned earlier, the objective function maximizes capital investments which are restrained to have a net positive payoff. From other studies, education is known to have a high positive return. Of

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[6]Appendix B of General Social and Economic Characteristics, [25].

Table 9. Distribution of workers by occupation to industry.

Occupation	Agriculture	Construction	Manufacturing	Transportation	Trade	Finance, insurance & real estate	Business services	Personal services	Entertainment	Professional	Public Administration
Professional & technical		X	X							X	
Managers & administrators		X	X	X	X	X	X		X	X	X
Sales workers			X		X	X	X	X			
Clerical		X	X	X	X	X	X	X		X	X
Craftsmen		X	X		X		X				
Operatives		X	X		X		X	X	X		X
Transport		X	X	X	X		X				X
Laborers		X	X	X	X		X	X			X
Farmers & farm managers	X										
Farm laborers	X										
Service workers					X	X	X	X	X	X	X
Private household workers								X			

Table 10. Input of workers by occupation to industry.

Occupation	Industry										
	Agriculture	Construction	Manufacturing	Transportation	Trade	Finance, insurance & real estate	Business services	Personal services	Entertainment	Professional services	Public administration
Professional & technical	--	.0067	.0081	--	--	--	--	--	--	.5030	--
Managers & administrators	--	.0834	.0406	.1315	.1452	.2884	.1426	--	.2857	.1119	.1256
Sales workers	--	--	.0688	--	.1587	.1944	.0957	.0775	--	--	--
Clerical	--	.1163	.1417	.1836	.1330	.4013	.1979	.1599	--	.1564	.1756
Craftsmen	--	.5075	.1833	--	.1720	--	.2553	--	--	--	--
Operatives	--	.1468	.4358	--	.0801	--	.1191	.0962	.2381	--	.1061
Transport	--	.0467	.0568	.6000	.0534	--	.0787	--	--	--	.0707
Laborers	--	.0926	.0651	.0849	.0615	--	.0511	.0408	--	--	.0817
Farmers & farm managers	.7748	--	--	--	--	--	--	--	--	--	--
Farm laborers	.2252	--	--	--	--	--	--	--	--	--	--
Service workers	--	--	--	--	.1961	.1160	.0596	.1903	.4762	.2288	.4402
Private household workers	--	--	--	--	--	--	--	.4353	--	--	--

course, the net benefits over time from investment in education would be much greater than the capital investment in the given time period.

Capital

To institute the model, capital resources were divided into two major categories. Liquid capital was defined as those deposits held by banks of the five counties. It was not possible to distinguish which productive sector of the area economy maintained control over these assets.

Capital stock was defined as the current value of fixed and working assets held by the various productive sectors in the area. Current land values were not included in any sector, due to the constancy of the total over the years of the model and the fact that land is one of the basic resources considered. Capital improvements in the land were included as described in other parts of this report.

The capital resources enumerated for the area included the following:

Liquid bank deposits	$236,328,000 [1]
Agricultural buildings	45,000,000 [21]
Agricultural machinery	94,000,000 [21]
Industrial buildings and machinery	61,000,000[7]
Commercial buildings and equipment	214,000,000[7]
Recreational improvements	262,000[7]

Capital resources in the public sector were not included.

Earnings from productive activities were divided where possible into (a) wages and salaries and (b) entrepreneural incomes. The public sector was not allowed to earn entrepreneural incomes (which otherwise would be included in carry-over tax collections). Two sectors of the model economy, agriculture and

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[7] Estimate based on national average investments per employee.

recreation, included only entrepreneural incomes reflecting the high proportion of owner-operators.

Figure 2 indicates the "micro money flow" of the model under static conditions. Following through the model, we proceed as follows:

(1) Productive activity obtains capital from investment capital of its own sector.

(2) Profits from the activity are divided between entrepreneural income and wage and salary payments.

(3) Wages and salaries are first spent on consumption goods, the remainder going to savings in the "bank."

(4) Entrepreneural incomes are either reinvested in productive activities within their own sector or placed in the "bank."

(5) The "bank" can make investments in any sector of the model.

The picture appears somewhat more complex when considering a multiperiod model as in Fig. 3. However, transfers from one time period to the next provide the only changes. All the income earned in one time period in the dynamic model cannot be invested in productive activities of the same period. The assumption was made that only half of the entrepreneural income and one-half of the savings are invested in productive activities of the current time period. The remaining half of each is transferred as investment to the next time period. In the final time period of the model, this latter half is deposited in the "bank" (i.e., is not invested).

Investment capital is derived from four sources: (a) current capital investments including bank deposits, (b) savings from wages and salaries, (c) entrepreneural income, and (d) moneys imported from outside sources and repaid plus interest. Two additional resources are important to the development potential of the area. The first is the recreation-tourism potential, and the second is the attitude of the residents of the area toward work endeavors and economic development.

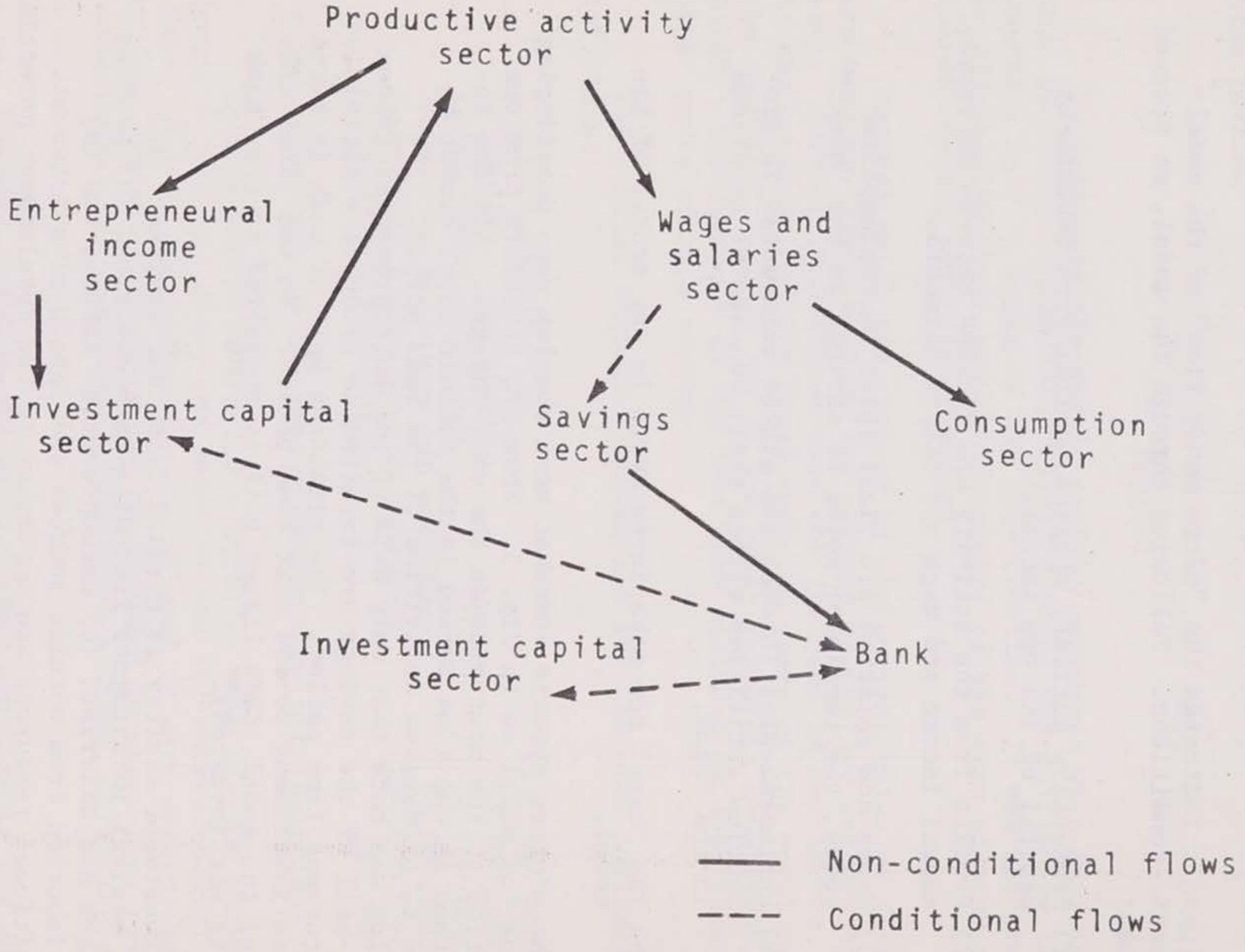

Fig. 2. Micro money flow diagram (static model).

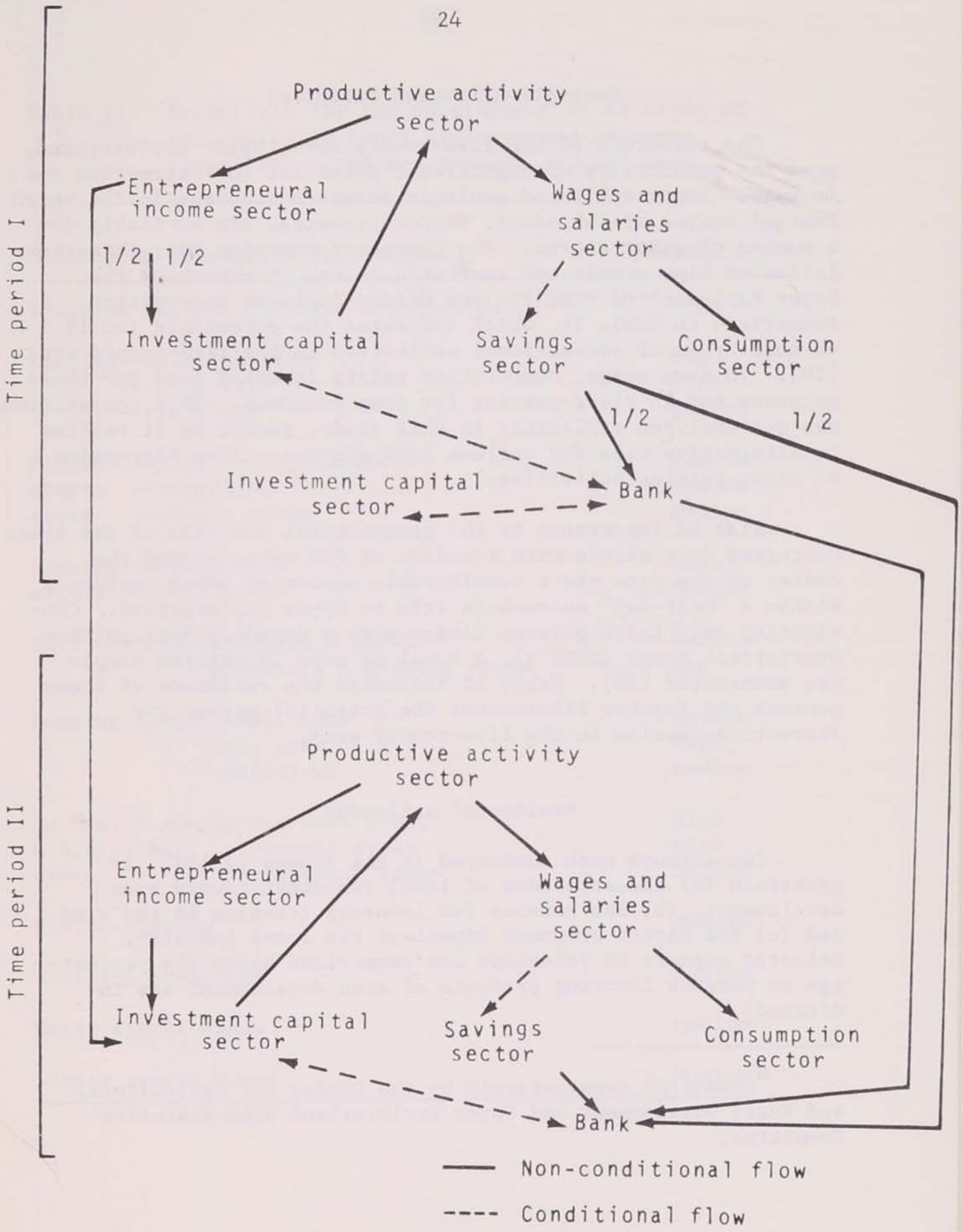

Fig. 3. Micro money flow diagram (multiperiod model).

Recreation-Tourism Potential

The resources of the five-county area, Upper Explorerland, pose the possibility of significant potential for recreation and tourism. Topographic and geologic formations unique in the north central states are abundant. Water resources are available for a number of water sports. The landscape contains many characteristics of high scenic and aesthetic value. A report by the Upper Explorerland RC&D Project Office includes information, summarized in Table 11, which indicates the potentials for 12 various types of recreational activities in the five-county area [20]. In some cases, competition exists in using land for these purposes and in clear-cutting for crop purposes. This competition was not analyzed explicitly in this study, except as it realtes to alternative uses for various land classes. (See discussion of clear-cutting activities.)

Also of importance is the geographical location of the area. Contained in a circle with a radius of 200 miles around the center of the area are a considerable number of urban residents within a "half-day" automobile trip to Upper Explorerland. Considering only those persons living within Standard Metropolitan Statistical Areas (SMSA's), a total of over 13 million people are enumerated [22]. Table 12 indicates the residence of these persons and further illustrates the potential market for recreation-tourism in the five-county area.

Residents' Attitudes

Two surveys were conducted in the summer of 1972[8] to ascertain (a) the attitudes of local residents toward area development, (b) the reasons for industry locating in the area, and (c) the direct economic impact of the local industry. Selected aspects of relevance are summarized where the percentage of persons favoring products of area development are indicated:

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[8]Conducted cooperatively by the Center for Agricultural and Rural Development and Upper Explorerland RC&D Executive Committee.

Table 11. Potentials for the development of 12 kinds of recreation in Upper Explorerland Resource Conservation and Development project area.

Kinds of recreation development		Project area possibility
Vacation cabins, cottages & homesites		High
Camping	--vacation site	High
	--canoe trip	High
	--transient	Medium
Picnic & sports areas	--game, play, target	Medium
	--bicycling	Medium
	--picnic areas	Medium
Fishing waters	--warm waters	High
	--cold waters	Medium
Golf courses	--standard & par-3	Medium
	--miniature & driving range	Low
Hunting areas	--small game	Medium
	--big game	High
	--waterfowl	Medium
Natural & scenic & historical areas	--natural areas	High
	--scenic areas	High
	--historic areas	Medium
Riding stables		Medium
Shooting preserves		Medium
Water sports areas		Medium
Winter sports areas		Medium

Table 12. Residents of S.M.S.A.'s within 200 miles of Upper Explorerland

S.M.S.A.	Population 1970
Iowa	
Cedar Rapids	163,213
Davenport	266,119
Des Moines	286,101
Dubuque	90,609
Waterloo	132,916
Illinois	
Chicago	6,978,947
Peoria	341,979
Rockford	272,063
Rock Island-Moline	362,638
Minnesota	
Minneapolis-St. Paul	1,704,423
Rochester	56,604
Wisconsin	
Appleton-Oskosh	276,891
Green Bay	158,244
Kenosha	117,917
LaCrosse	80,468
Madison	290,272
Milwaukee	1,403,688
Racine	170,838
Total	13,153,930

(1) Aspects of life that appeal to residents:

Attractive surroundings or life style	53%
Business interests or job opportunities	37%
Other	10%

(2) Income increases required to encourage residents to leave area:[9]

0-10% increase	21%
25-50% increase	27%
100% increase	5%
Would not consider	47%

(3) Would favor increased industry if commercial services were improved:[9]

Yes	84%
No	10%
No opinion	6%

(4) Would favor increased tourism if commercial services were improved:[9]

Yes	70%
No	22%
No opinion	8%

(5) Industry managers' opinion of employee loyalty:[10]

Average	25%
Above average	54%
Very loyal	21%

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[9] 200 households were surveyed.

[10] 28 industry managers were surveyed.

(6) Industry managers' opinion of employee productivity:[10]

Below average	10%
Average	25%
Above average	54%
Much above average	11%

These opinions indicate a positive attitude of the population toward work and community development. Of further interest, however, are two questions asked of the residents to ascertain how they perceive their home community as to its size and ability to fulfill the needs of the population. The questions and sample responses were:

(1) Do you think this community is:

Too big?	0%
Too small?	20.4%
About right?	79.6%

(2) How does this community rate as it relates to your needs?

Excellent	19.1%
Good	37.6%
Average	38.3%
Poor	3.5%
Very poor	1.4%

These replies indicate a high level of satisfaction with the present status of communities in the area. Somewhat in conflict with answers to the previous set of questions, these opinions reflect the most difficult problem associated with rural community development. Various population strata make up all rural areas. Since their preferences differ by age, occupational group, sex, and other attributes, a rural development program emphasizing a single dimension or element does not equally advance the welfare of all these strata. A major problem is that of molding development programs which meet the major needs and preferences of these various strata without an overly extended

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[10] 28 industry managers were surveyed.

diffusion of resources and which do not create a major negative impact for one strata in order to attain positive gains for another.

ECONOMIC SECTORS AND DEFINITION OF ACTIVITIES

The economy of Upper Explorerland was divided into five productive sectors and one consumptive sector for this study. The productive sectors are agriculture, industry, commerce, recreation-tourism, and public. Agriculture and industry, the primary production sectors, are not affected by demand restraints due to the minuteness of the supply possible from the area in comparison to total supply in the U.S. economy.[11] All activities of these two sectors have a "purely competitive position" in the model.

The three secondary production sectors--commerce, recreation-tourism, and public--are demand driven. This condition requires that activities within these sectors must enter the solution at the prescribed level in order to satisfy demands for products or services expressed by other activities of the model.[12] Figure 4 indicates the basic flow of goods and services to the consumption sector. The consumption sector receives goods and services from the three secondary production sectors. In turn, this sector provides labor and capital to the primary and secondary production sectors. A second aspect of final demands is the "rest of the world" or exports. As discussed above, when domestic demands[13] for products from the primary production sectors are satisfied, the balance of production can be exported regardless of quantity.

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[11] Demand restraints are not difficult to consider in a linear programming model once they are enumerated. It was decided not to do so for this study.

[12] For example, public activities expand only to that point where demands for public services are met. Such activities are not allowed to increase beyond this point even though they may be profitable and (or) increase the objective function value.

[13] Defined as being demands from within the five-county area.

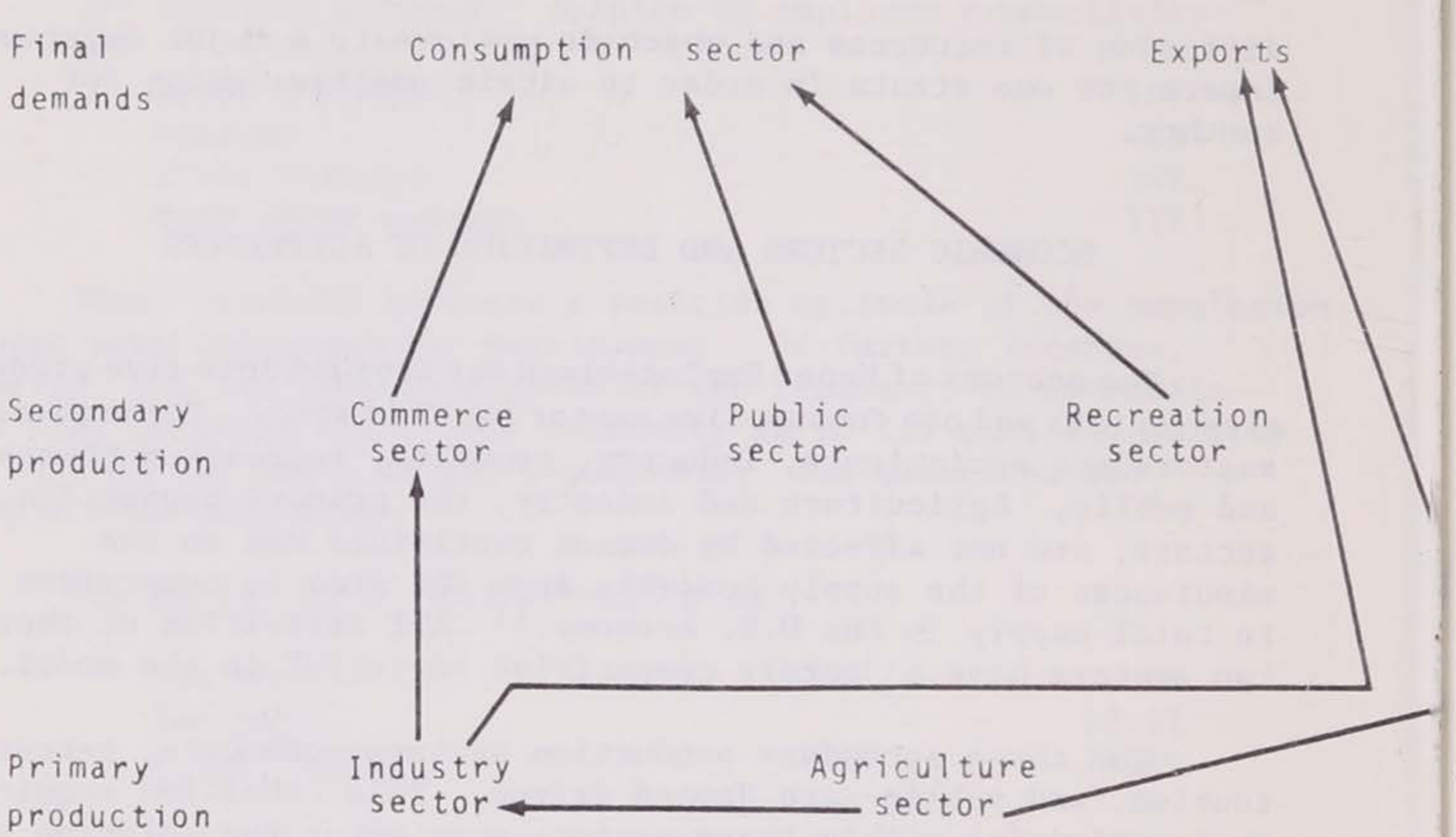

Fig. 4. Flow chart of goods and services in the area economy.

A coding system was utilized which identified the activities and restraints (columns and rows) of the model. The code numbers are five digit numbers, such as "ijkkk," where: the first digit represents the time periods, i=1, 2, 3; the second digit represents economic sectors or restraint types, j=0, 1, . . . 9; and the third through fifth digits represent specific activities or restraint number, kkk-000, . . ., 999.

Agriculture Sector

Information on agricultural production is abundant and localized. Data used to develop agricultural activities were taken from a number of studies [6, 11, 19, 7, 12]. A total of 84 agricultural activities were defined for each of the three time periods of this model. By major categories these are as follows: 11 livestock production activities, 15 rotation cropping activities, 18 land use changing activities, 20 permanent pasture activities, and 20 forest activities. A partial listing of activities and associated coefficients are illustrated in the following sections. A complete listing of all activities in the model is found in a later section.

Livestock activities

Livestock production activities considered included swine production under three levels of technology, beef production under two levels of technology and two beginning weight classes, beef cows producing calves, dairy with two grades of product, and a poultry activity defined in terms of turkey production. Coefficients used are indicated in Table 13. Livestock and feed prices used in the base model were: live hogs, $19.00 cwt.; live cattle, $20.00 cwt.; yearling feeder cattle, $30.00 cwt.; feeder calves, $32.00 cwt.; grade B milk, $4.00 cwt.; grade A milk, $5.00 cwt.; poultry, $.24 lb.; corn equivalent, $1.10 bu.; protein concentrate, $5.50 cwt.; and forage, $44.00 ton TDN.

Rotation cropping activities

Cropping activities were developed considering the maximum

Table 13. Coefficients for livestock activities.

Item	Activity number and name				
	11201[a] Sow and litters	11204[b] Yearling steer	11208[c] Beef cow	11210[d] Dairy cow	11211[e] Turkey
Inputs					
Labor (hr.)	30	15	9	90	130
Corn (bu.)	184	60	2	94	905
Forage (lb. TDN)	1,350	1,500	5,600	9,000	0
Oilmeals (lb.)	2,000	170	100	1,060	23,700
Capital ($)	231	220	64	204	2,500
Buildings ($)[f]	10	16	5	20	200
Supplement ($)[g]	151	14	16	134	1,700
Livestock ($)[h]	70	190	43	50	600
Outputs					
Red meat (lb.)	3,436	1,135	143	500	0
Beef calves (lb.)	0	0	430	0	0
Milk (lb.)	0	0	0	11,000	0
Poultry meat (lb.)	0	0	0	0	21,000

[a]One sow and two litters, average technology.

[b]One yearling steer, low level of technology.

[c]One beef cow, average level of technology.

[d]One dairy cow producing grade B milk.

[e]1000 turkeys, average level of technology.

[f]Annual cost of buildings and equipment.

[g]Includes protein concentrates, veterinary, medications, etc.

[h]Annual cost of livestock ownership.

annual soil loss of four tons per acre. Therefore, crop intensity decreases as land slope increases. Rotation cropping activities were considered only for land capability classes of I, II, III, and IV as discussed earlier. Likewise, rotation cropping was allowed only on crop pattern classes A, B, and C. (Cropping activities and associated coefficients are illustrated in Table 14.) Prices of crop outputs used were: corn, $1.10 bu.; soybeans, $2.50 bu.; forage, $44.00 ton TDN.; vegetables (beans), $78.00 ton; and, vegetables (tomatoes), $35.00 ton.

Land use changing activities

Four types of activities are included in this category including drainage, conservation, land clearing, and conversion of pasture to cropland. The drainage activities convert land of sub-class B to sub-class A. Similarly the conservation activities convert land of sub-class C to sub-class A. Land clearing activities convert land of sub-class F to sub-class C. The pasture conversion activities convert land of sub-class D to sub-class C. Conservation activities are divided into these three types: (a) conservation I--stripcropping and contour cropping, (b) conservation II-terraces and contour cropping, and (c) conservation III--parallel terraces and contour cropping. Additions to the objective function are provided by the drainage and conservation activities II and III since long-run productivity of the land resource is increased. Table 15 summarizes these land use changing activities.

Permanent pasture activities

Two permanent pasture activities are provided for in the model. Pasture can be produced on land sub-classes D, E, F, and G under traditional management methods or on land sub-classes D and E under a management system which calls for periodic renovation. Table 16 describes these activities. Labor and capital requirements increase in the year the renovation of pasture takes place.

Forest activities

Four types of activities are included for forestry. These

Table 14. Coefficients for rotation cropping activities.

Item	Activity number and name			
	11101[a] Continuous corn	11102[b] Corn-soybeans	11103[c] Rotation	11115[d] Vegetables
Inputs				
Land (acres)	1	2	6	1
Labor (hrs.)	6	11	42	30
Capital ($)	50	80	248	95
Machinery ($)[e]	12	20	72	12
Supplies ($)[f]	38	60	176	83
Outputs				
Corn equivalent (bu.)	110	110	370	0
Oilseeds (bu.)	0	40	0	0
Forage (lbs. TDN)	0	0	9,000	0
Vegetables (tons)	0	0	0	20

[a] One acre continuous corn on land I-A.

[b] Two acres corn-soybean rotation on land I-A.

[c] Six acres CCCOMM rotation on land II-A.

[d] One acre labor intensive vegetables (tomatoes) on land I-A.

[e] Annual cost of machinery ownership.

[f] Cost of fertilizer, chemicals, petroleum products, etc.

Table 15. Coefficients for land use changing activities.

Item	Activity number and name				
	11001[a] Drainage	11021[b] Conservation I	11031[c] Conservation II	11011[d] Clearing	11061[e] Land transformation
Inputs					
Land (A)	1	1	1	1	1
Capital ($)	200	5	70	200	0
Outputs					
Land (A)	1	1	1	1	1
Objective function values					
Period I ($)	149	0	52	0	0
Period II ($)	174	0	61	0	0
Period III ($)	200	0	70	0	0

[a]Drainage of one acre of land class I-B creates one acre of land class I-A.

[b]Conservation I on one acre of land class I-C creates one acre of land class I-A.

[c]Conservation II on one acre of land class II-C creates one acre of land class I-A.

[d]Land clearing on one acre of land class I-F creates one acre of land class I-C.

[e]Convert one acre of land class I-D to one acre of land class I-C.

Table 16. Coefficients for permanent pasture activities.

Item	Activity number and name	
	11041[a] Renovated pasture	11066[b] Regular pasture
Inputs		
Land (A)	1	1
Labor (hrs.)	7	3
Capital ($)[c]	0	0
First period	25	3
Subsequent periods	15	3
Outputs		
Forage (lbs. TDN)[d]	2,250	900

[a]One acre renovated pasture on land class I-D. Labor requirement includes three hours first year and two hours each subsequent year.

[b]One acre non-renovated pasture on land class I-D. Labor requirement is one hour per year.

[c]Capital requirement for period renovation takes place is higher than in subsequent periods.

[d]Annual production.

are (a) harvest of existing mature forest stands, (b) clear cutting existing forest, (c) a forestation of non-forest land, and (d) planting Christmas trees. The harvest of existing forest stands implies selective cutting, whereas clear cutting relates to complete deforestation of the land. Increases in the objective function value occur in a forestation, Christmas tree planting, and forest harvest activities. Table 17 includes production coefficients for the forest activities.[14]

Industry Sector

Basic data for industrial activities were derived from two sources. The first source the report Industry Profiles [26], includes industries categorized by the "Standard Industrial Classification" (S.I.C.) system of two-, three-, and four-digit classes. The second source was the study, Input-Output Structure of the U.S. Economy 1963 [27]. The industrial classes in the latter report were independently numbered categories but were cross referenced to relate to S.I.C. code numbers.[15]

The data in Industry Profiles was aggregated into "per industry"[16] classes. That data from Input-Output Structure was aggregated on the basis of per dollar of output. It was desired to develop industrial activities using one man-year as the base unit. This transformation, the convession of all coefficients on inputs and outputs to the basis of a man-year, required a

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[14] Sources of data for forest activities are: Forestry Returns Evaluated [15], Iowa Forest Industry Potential [5], and A Decision-Making Guide for Christmas Tree Production [10].

[15] The input-output study did not contain as many classes as the Industry Profiles study, and in some cases the aggregation was significantly different between the two studies.

[16] Two-, three-, and four-digit S.I.C. categories.

Table 17. Coefficients for forest activities.

Item	Activity number and name			
	11131[a] Forest harvest	11141[b] Clear cut	11051[c] Tree plant	11055[d] Xmas trees
Inputs				
Land (A)	1	1	1	1
Capital ($)	0	0	60	288[e]
Labor (hrs.)	0	0	20	184[f]
Outputs				
Forest products ($)	9	225	0	2,200[g]
Objective function values				
Period I ($)	25	0	45	0
Period II ($)	25	0	30	1,803[g]
Period III ($)	25	0	15	1,467[g]

[a]Harvest forest products from one acre of land class I-F.

[b]Clear cut one acre of land class I-F.

[c]Plant trees on one acre of land class IV.

[d]Plant Christmas trees on one acre of land class VI.

[e]Cost is divided among time periods as follows: Period I--$140, II--$50, III--$98.

[f]Labor requirement is divided among time periods as follows: Period I--41 hrs., II--56 hrs., III--87 hrs.

[g]Christmas trees planted in time period I can be harvested in time period III. Plantings in later periods can not be harvested within the time frame of the model and thus appear as increases in objective function value.

large amount of data processing for developing production industrial coefficients to be included in the model.

Selection of industrial activities

A total of 88 industrial activities were defined for inclusion in the model. The selection was made using three criteria: First, industries were included if they were currently in existence in the area. Second, selection was made of representative industries which require significant quantities of inputs available in the area. Such inputs considered to be plentiful were low-skilled labor, agricultural products, forest products, and certain minerals (limestone, sand, and gravel). Third, selection based on relevance to the area was accomplished after the first two criteria were applied. It was observed that some industries selected under criteria one and two required large amounts of imported inputs and would be prospective only if profitability was sufficiently great. These industries were included in the model if they did not violate criterion two to an unreasonable degree. After applying these criteria in the model, 102 industries were selected for the model.

Development of production coefficients

As stated above, industrial activities were developed on a one man-year basis, and data were processed in the following steps:

(1) A "value of shipments per employee" was calculated using the "total value of shipments" figure and dividing by "total employees" for each industry using 1969 figures from Industry Profiles [26].

(2) Data from the direct requirements table of the Input-Output Structure [27] indicates the allocation of one dollar of output among all contributing inputs plus a value-added figure which represents profit and labor costs. This data was sorted for each of the 102 industries. Only inputs which comprised more than one percent of output values were included separately to allow easier data handling and a smaller model. All inputs under one percent

of the total were included in the residual inputs category.

(3) The percentage figures determined in step two were then multiplied by the "value of shipments per employee," which was assumed to be analogous to "value of output per employee," to obtain the dollar value of various inputs used per employee.

(4) A comparison of the 102 industries with the data calculated in step three indicated which of the required inputs could be produced in the area. The remainder plus the residual inputs were assigned to be imports.

(5) A final survey of industries being considered indicated that some could be aggregated.[17] Others were deemed to be of insignificant size and thus were deleted. This final selection reduced the number for the model to 88 industries.

Finally, the coefficients prepared for the model from the above steps were calculated on per man-year basis.

For the input requirements, elements were calculated as follows:

(1) Capital stock requirement = the "book value of assests per employee (1964)"[18] multiplied by an inflation factor of 1.14[19] to update to 1969.

(2) Investment capital requirement = the "value of shipments per employee" figure minus "entrepreneural

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[17] In the case of aggregating two or more industries, the coefficients used were simple averages of the data from the individual industries.

[18] From Industry Profiles [26], 1969 data.

[19] Inflation factor = $\frac{\text{1969 Wholesale Price Index}}{\text{1964 Wholesale Price Index}}$; $114 = \frac{115.1}{100.8}$

income per employee," calculated in number four below.

(3) Labor costs = the "total employees payroll"[20] figure divided by "total employees."

(4) Entrepreneural income = the "labor costs per employee" figure subtracted from "value added per employee," calculated above.

(5) Output = "value of shipments per employee," calculated above.

(6) Labor requirement = one man-year.

All industrial activities included the six statistics or elements above plus those involved with input requirements and output. Table 18 displays a sample of the 88 industrial activities of the model and their associated coefficients. A complete listing of activities is provided later.

Investment capital requirement includes a depreciation factor to maintain the buildings and machinery at a constant level of efficiency. Industrial expansion activities are instituted with a per unit investment requirement equal to that indicated as the "capital stock" input. These expansion activities are the only entries in the objective function in the industry sector. New industrial activities are not allowed to occur until the capital stock, indicated in a later section, is exhausted.

Commercial sector

A total of 15 categories of commercial activities were included in the model. These categories are indicated in Table 19. The data were developed to describe the commercial activities on the basis of a man-year of labor input.

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[20] From Industry Profiles [26], 1969 data.

Table 18. Coefficients of industrial activities.

Item	Activity number and name			
	12015[a]	12054[b]	12074[c]	12086[d]
Inputs[e]				
Capital stock ($)	9,407	10,048	11,617	4,974
Investment capital ($)	25,146	20,523	28,109	17,776
Labor costs ($)	5,344	8,188	8,307	5,711
Labor (man-year)	1	1	1	1
Forest products ($)	7,757	--	--	--
Sawmill products ($)	676	--	--	--
Metal services ($)		290	--	--
Wholesale services ($)	--	399	1,222	775
Paperboard containers ($)	--	--	--	421
Plastic materials ($)	--	--	--	635
Screw machine products ($)	--	--	--	333
Metal stampings ($)	--	--	--	1,483
Residual ($)	11,369	11,846	18,580	8,418
Outputs				
Entrepreneural income ($)	717	4,917	6,961	4,023
Output ($)	25,863	25,440	35,070	21,799
Labor payments ($)	5,344	8,188	8,307	5,711

[a]Logging.

[b]Screw machine products.

[c]Storage batteries.

[d]Buttons.

[e]Annual data is presented.

Table 19. Commercial activities.

Activity number	Commercial business categories
13031	Grocery stores
13032	Restaurants
13033	Furniture and appliance stores
13034	Clothing and department stores
13035	Variety, drug, and hardware stores
13036	Auto, sales and service
13037	Building materials
13038	Medical service
13039	Financial and legal services
13040	Personal services
13041	Miscellaneous services
13043	Transportation services
13045	Wholesale services
13201	Agricultural machinery and equipment
13202	Agricultural supplies

Definition of coefficients

Data utilized to develop coefficients for the commercial activities was, by necessity, derived from three major sources. County Business Patterns [23] provided information on employment and salaries. The 1967 Census of Business [24] provided data on numbers of establishments and total amount of gross sales by category. A publication by Dun and Bradstreet [4] indicates the breakdown of gross sales into various types of costs for commercial activities. Information from these sources is summarized in Table 20.

This data was converted to a man-year basis by a simple division process. The resulting coefficients used to describe the commercial activities in the model are indicated in Table 21.

The mechanics of the commerce sector are similar to these of the industry sector discussed previously. The primary difference in the sector is demand, which is limited in that the activities are not allowed to produce more than the consumption-derived demand requires.

Recreation-Tourism Sector

Tourism is considered by the residents of Upper Explorerland to be a significant prospect in future development of the area. To reflect this possibility, a group of tourism activities were specified in the model. Data on recreation-tourism activities is very sparse, particularly with regard to inputs. Most research dealing with recreation-tourism demands uses the concept of a visitor night. This unit is relevant to the current study for two reasons. First is the availability of data, and second is the assumption that tourist activities are planned and conducted in relation to overnight stays.

Two activities were developed to reflect tourist demands on the economic structure of the five-county area. One includes effects resulting from outdoor camping and the second from overnights in motels or hotels. These two activities are outlined in Table 22. These two activities place demands on commercial services which are satisfied by activities of that sector. The

Table 20. Commercial service establishments basic data.

Item	Activity number				
	13031	13032	13033	13034	13035
Employees per establishment	9.27	6.06	4.83	6.05	14.22
Payroll per establishment ($)	29,571	12,647	22,078	18,688	48,931
Sales per establishment ($)	367,708	57,567	147,698	137,552	353,983
Profit per dollar sales ($)	.055	.110	.170	.150	.150
Profit per establishment ($)[a]	20,224	6,332	25,109	20,633	53,097
Capital stock per establishment ($)	54,415	28,179	43,349	63,279	88,150

	Activity number				
	13036	13037	13038	13039	13040
Employees per establishment	5.07	14.22	7.76	3.77	10.23
Payroll per establishment ($)	21,365	56,880	44,418	13,848	33,884
Sales per establishment ($)	245,440	489,052	555,228	40,204	101,612
Profit per dollar sales ($)	.090	.500	.300	.200	.250
Profit per establishment ($)[a]	22,090	244,526	166,568	8,041	25,403
Capital stock per establishment ($)	46,264	277,062	252,073	36,284	66,045

	Activity number				
	13041	13043	13045	13201	13202
Employees per establishment	5.45	7.58	9.92	6.38	4.58
Payroll per establishment ($)	13,620	47,997	67,456	30,522	21,993
Sales per establishment ($)	58,587	378,500	2,000,000	309,522	361,164
Profit per dollar sales ($)	.200	.139	.077	.090	.100
Profit per establishment ($)[a]	11,717	51,460	154,000	35,151	36,116
Capital stock per establishment ($)	56,767	288,912	241,998	32,608	95,708

[a]Profit per establishment = (sales per establishment) X (profit per dollar sales).

Table 21. Coefficients for commercial activities.

Item	Activity number				
	13031	13032	13033	13034	13035
Inputs					
Labor (man-years)	1	1	1	1	1
Capital stock ($)	5,870	4,650	8,975	10,459	6,199
Investment capital ($)	37,484	8,455	25,380	19,325	21,159
Labor payments ($)	3,190	2,087	4,571	3,089	3,441
Outputs					
Sales ($)	39,666	9,499	30,579	22,736	24,893
Entrepreneural income ($)	2,182	1,045	5,199	3,410	3,734
Labor payments ($)	3,190	2,087	4,571	3,089	3,441

	Activity number				
	13036	13037	13038	13039	13040
Inputs					
Labor (man-years)	1	1	1	1	1
Capital stock ($)	9,125	19,484	31,195	9,651	6,456
Investment capital ($)	44,053	17,196	50,085	8,531	7,616
Labor payments ($)	4,214	4,000	5,724	3,644	3,322
Outputs					
Sales ($)	48,411	35,490	71,550	10,664	9,933
Entrepreneural income ($)	4,357	17,196	21,465	2,133	2,483
Labor payments ($)	4,214	4,000	5,724	3,644	3,322

	Activity number				
	13041	13043	13045	13201	13202
Inputs					
Labor (man-years)	1	1	1	1	1
Capital stock ($)	10,416	38,115	24,395	5,111	20,897
Investment capital ($)	8,600	43,133	186,089	55,708	70,971
Labor payments ($)	2,499	6,332	6,800	4,784	4,802

Table 21 continued.

Table 21 continued.

Item	Activity number				
	13041	13043	13045	13201	13202
Outputs					
Sales ($)	10,750	49,921	201,613	61,218	78,857
Entrepreneural income ($)	2,150	6,788	15,524	5,510	7,886
Labor payments ($)	2,499	6,332	6,800	4,784	4,802

Table 22. Coefficients for demands created by recreation-tourism activities.

Item	Activity number	
	15100[a]	15200[b]
Grocery stores--13031 ($)	6.81	2.04
Restaurants--13032 ($)	3.37	8.12
Clothing & dept. stores--13034 ($)	1.23	1.23
Variety, drug, & hardware--13035 ($)	3.72	3.72
Auto sales & service--13036 ($)	6.05	6.05
Miscellaneous service--13040 ($)	.50	10.28
Recreation--13045 ($)	3.85	3.85

[a]Recreation-tourism camping activity.

[b]Recreation-tourism motel-hotel activity.

data used to develop such demands were taken from the study, "Characteristics of Automobile Travelers in Iowa" [3]. This report is a summary of a survey to determine the economic impact of various types of travelers in Iowa. The coefficients used were adjusted to reflect more accurately the two specific activities in the model.[21]

Two other activities are important in the tourism sector. One is an activity to develop new campgrounds, and the other is a campground management activity. There are presently approximately 1310 spaces available in Upper Explorerland for camping in all types of campgrounds. Estimates by campground managers interviewed in the area are that 10 camping spaces can be developed on an acre of relatively flat land. Land with a topography less favorable

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[21]All data were inflated by 10 percent to reflect increased price levels. A food expenditure of $10.18 was divided between demands on grocery stores and restaurants on the basis of 67 percent and 33 percent for campers and 20 percent and 80 percent for those overnighting in motels or hotels. Costs for motels and hotels are included in miscellaneous services.

to camping sites is suggested for such supporting activities as hiking, horseback riding, and other recreational activities. It was estimated that a capital investment of $2,000 per acre is required to prepare land for campgrounds.[22]

Further estimates concerning campground development and management are these: (a) One man is able to manage 10 acres of campground. (b) An average touring group includes four persons. (c) The average cost per person for campground services is one dollar per night. (d) Average occupancy of campground spaces is 25 percent. (e) Net returns to operator, exclusive of investment costs, are 50 percent of gross sales.

The estimated demands for recreation-tourism services are taken from projections developed by the Iowa State University Cooperative Extension Service [14]. Recreation participation in this report is estimated for 14 counties of northeast Iowa. It was assumed that two-thirds of the projected activity would take place in Upper Explorerland due to the comparative advantages of the area. The projection for camping is 548,000 visitor nights per year for 1975 and 608,000 for 1980. Demands for non-camping tourists were assumed to be 25 percent of that for campers. Actual tourist demands used in obtaining model solutions are indicated in Table 23.

Table 23. Annual tourist demands.

Time	Visitor nights	
	Campers	Non-campers
Time period I	365,334	91,334
Time period II	385,334	96,334
Time period III	404,666	101,186

[22]Data used for this and subsequent estimates concerned with camping activities are taken from interviews with campground managers of the five-county area and other written references. See [2], [29], [9], [16], [8], and [13].

Public Sector

The average per capita 1970 expenditure by state and local governments was $540 in Iowa [17]. Expenditures include education, highways, public welfare, health, police protection, fire protection, and sewerage. This amount was used in the model as the per capita demand for state and local governmental services and conversely as the supply of tax monies provided per capita for financing such services.

Approximately 4.2 percent of the population of rural counties of Iowa are engaged in the governmental services listed above [25]. This parameter was also used in the model requiring that 42 persons per one thousand population be employed by governmental agencies. This labor requirement was assumed to be comprised of 50 percent public administration workers and 50 percent professionals (see Table 10) due to the inclusion of public education and health services in the public sector.

The Biennial Report of County Finances [18] indicates the dispersement of monies by local governments. A cursory summarization of this data indicates that such governmental expenditures are allocated approximately as follows: 40 percent salaries and benefits, 35 percent construction and maintenance, 15 percent office and administrative supplies, and 5 percent travel. These estimates were used to determine demands on other sectors of the model created by the public sector.

Consumption Sector

A single activity in each time period is defined to provide for consumption by the area residents. The July 1971 issue of Survey of Current Business provides data for 1970 which indicates the total expenditures by the U.S. population in twelve major consumption categories. These twelve are further divided into 67 classes. The total per capita annual consumption expenditures in 1970 were $3,007.

The total per capita annual consumption requirement was rounded to $3,000 for use in this study. Aggregating the expenditure information into classes consistent with those of the commerce sector of the model, the annual per capita consumption requirements are as follows:

Grocery stores	$ 515
Restaurants	158
Furniture and appliance stores	165
Clothing and department stores	341
Variety, drug and hardware stores	217
Auto, sales and service	487
Building materials	64
Medical services	78
Financial and legal services	83
Personal services	82
Miscellaneous services	134
Construction industry	676
Total consumption expenditures	$3,000

These amounts are expressed as demands on the commerce and industry sectors created by each of the 95,672 area residents.

Accomplishment of Developmental Goals

One condition of this study, agreed upon by the committees leading the Upper Explorerland program, was that "in a developed area all persons should enjoy" 10 defined parameters. A discussion of these goals and the method used to incorporate each into the linear programming model is now presented. These 10 goals were specified in the model as minimum restraints to be met.[23]

Minimum per capita income

A minimum annual per capita income of $3,000 is specified as a goal for all 95,642 residents. Labor force participation thus is provided for all of the 35,730 workers on the basis of each worker's relative productivity.

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[23] A linear programming model is designed to select the mix of available resources which will maximize the objective function, given the restraints included in the model.

Educational opportunity

A per capita expenditure equal to the state average was considered a goal to provide adequate economic opportunities. Education was assumed to be provided by the public sector.

Medical care

A per capita expenditure equal to the national average was used as a goal to allow purchase of adequate medical care. Medical personnel and establishments with a customer base equal to the national average were assumed to provide adequate service.

Adequate housing

A calculated total expenditure of $18 million was necessary to improve all inhabited housing units to meet minimum standards.[24] This expenditure was specified in the model as a minimum restraint or goal.

Access to community services

Community facilities and services with a customer base equal to the national average was used as a goal to provide adequate service.

Outdoor recreation

The supply of outdoor recreational facilities and services was assumed to be adequate due to the unique characteristics of the area. Public expenditures equal to the state per capita

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[24]These standards were (a) exclusive use of an indoor bathroom by each family, (b) exclusive use of an equipped kitchen by each family, (c) hot and cold running water in the home, (d) telephone and electric service in the home, and (e) adequate heating facilities.

average were assumed to be sufficient to maintain the goal for public recreation facilities.

Public safety

The per capita expenditure in the public sector equal to the state average was considered sufficient to provide the goal of adequate public safety.

Public information

Information from the public sector was assumed to be provided as a result of the state per capita average expenditure requirement and to meet the associated goal. Private sector information dissemination was considered as a commercial service.

Worship and government

The freedom to worship and participate in the processes of government were considered as goals beyond the quantitative scope of the study.

Aesthetic community environment

All productive activities were considered relative to their inherent environmental problems. As a goal, no industrial activities would be allowed which produced large quantities of air or water pollutants. Cropping patterns which allowed more than four tons annual soil loss were not considered. Clear cutting of forest land was not allowed unless a cover crop of some type was planted.

THE PROGRAMMING MODEL

The linear programming model used in the study is illustrated

in this section. Figure 5 is a schematic representation in a simplified form of the model matrix. A discussion follows which indicates the purpose and content of the parts (sub-matrices) of the model.

Sub-matrices

Sub-matrices A_I, A_{II}, and A_{III} are identical with each containing production and consumption activities for one three-year time period. Activities utilize resources and produce outputs within each time period. Some outputs are in the form of resource modifications accomplished to increase the rate at which the rural development goals are attained.

Sub-matrices T_{I-II}, T_{I-III}, and T_{II-III} contain transfer coefficients which allow resource modifications in one time period to be transferred to the resource restraints of a later time period. For example, land which is terraced in the first time period enters the resource restraints of time periods two and three as terraced land.

Sub-matrices Y_I, Y_{II}, and Y_{III} contain output accounting coefficients which indicate the production from specified activities for each time period.

Matrix B is the resource restraint vector which contains the quantities of various resources available and accounts utilized by the transfer activities and output accounting rows.

Sub-matrix S contains (initially) the slack activities (i.e., initially the restraints) which allow the use of the mathematical equality in the individual equations. In practical terms, the slack activities allow quantities of resources to be unused if the optimization of the model requires.

The objective function is represented by sub-matrix Z in Fig. 5. Activities which add to investment capital have non-zero entries in the objective function. The model is then solved to maximize the value of this function.

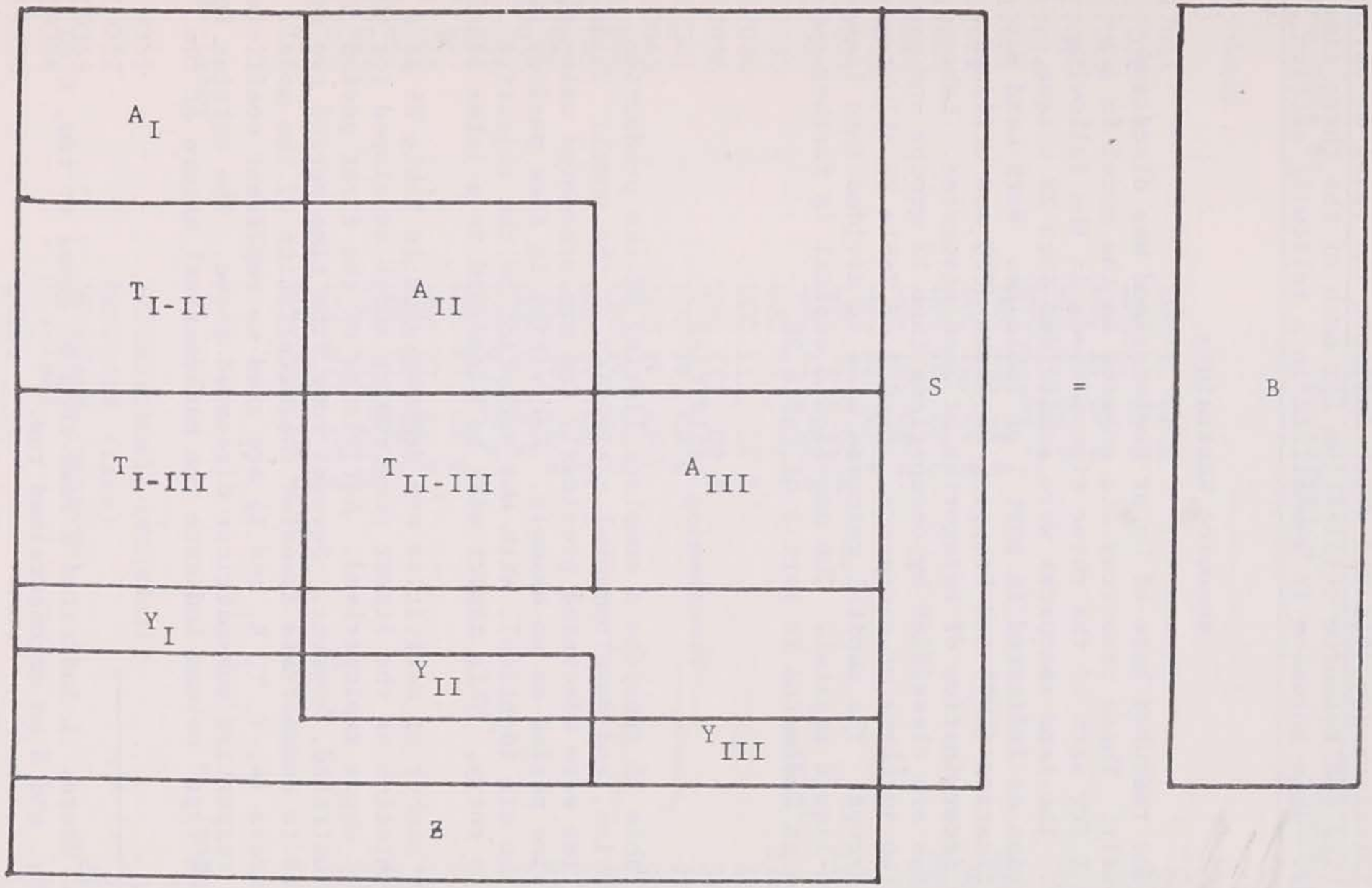

Fig. 5. Schematic representation of linear programming model.

Solutions are obtained which indicate the level of various activities and resource utilization for each of the three time periods. This solution is summarized in a following section.

Resource Restraints

The resource base of Upper Explorerland was discussed previously. These resources are entered in the model in sub-matrix B for each of the three time periods in the following manner: The land resources were subdivided into 28 unique categories as indicated in part 1 of Table 24. Both Land Use Classification (LUC) and Cropping Patterns (CP) are utilized in the determination of categories of land resources. Labor resources are classified by occupations into 12 groups and are indicated in terms of man-years. Part 2 of Table 24 illustrates these groups. The capital resource base is divided into liquid and non-liquid capital. The non-liquid capital is further sub-divided as indicated in part 3 of Table 24.

Programming Activities

Table 25 provides a complete listing of the production, consumption, and developmental activities of the model. These activities were discussed previously and are presented using the first time period as an example. Activities in time periods two and three are identical, with the exception of the objective function entry. This aspect will be discussed in a later section.

A number of activities are demonstrated in Table 26 as a representation of the linear programming model developed for the study of Upper Explorerland. Activities of the first period only are illustrated, however. Several rows from time period two are included to demonstrate transfer characteristics of the model. The letters (A, T, Y, B, and Z) are used to represent coefficients of the respective sub-matrices discussed above. The entries in the "row type" column indicate the mathematical nature of the rows.[25]

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[25] Where: L indicates a less than or equal to row, E an equality, and N an unconstrained row.

Table 24. Resource restraints for the model.

Resource code no.	Description	Initial quantity
Part 1--Land		(Acres)
17011	LUC I, CP A	58,081
17012	LUC I, CP B	12,576
17013	LUC I, CP C	855
17014	LUC I, CP D	20,177
17016	LUC I, CP F	7,044
17021	LUC II, CP A	205,346
17022	LUC II, CP B	96,806
17023	LUC II, CP C	305,533
17024	LUC II, CP D	55,470
17026	LUC II, CP F	17,110
17031	LUC III, CP A	121,211
17032	LUC III, CP B	527
17033	LUC III, CP C	378,914
17034	LUC III, CP D	68,181
17036	LUC III, CP F	57,024
17041	LUC IV, CP A	27,356
17043	LUC IV, CP C	92,924
17044	LUC IV, CP D	17,483
17045	LUC IV, CP E	17,483
17046	LUC IV, CP F	43,042
17055	LUC V, CP E	19,200
17056	LUC V, CP F	8,416
17065	LUC VI, CP E	50,408
17066	LUC VI, CP F	29,159
17067	LUC VI, CP G	22,285
17075	LUC VII, CP E	39,250
17076	LUC VII, CP F	195,072
17077	LUC VII, CP G	17,283
Part 2--Labor		(man-years)
19351	Professional, technical	3,054
19352	Managers (farm)	7,478
19353	Managers (nonfarm)	2,729
19354	Clerical	3,874
19355	Sales	1,850
19356	Craftsmen	3,704
19357	Operatives	3,314
19358	Service	3,990
19359	Farm laborers	2,238

Table 24 continued.

Resource code no.	Description	Initial quantity
19360	Laborers (nonfarm)	1,309
19361	Transport	1,464
19362	Private household	665
Part 3--Capital		(000 dollars)
17100	Liquid capital	236,328
17501	Agricultural machinery	94,000
17511	Agricultural buildings	45,000
17502	Industrial investments	61,000
17503	Commercial investments	214,000
17504	Recreational investments	262

Table 25. Activities of the linear programming model.[1]

Activity code no.	Description	Entry in objective function
Agricultural sector:		
11001	Drainage land I-B	x
11002	Drainage land II-B	x
11003	Drainage land III-B	x
11011	Clearing land I-F	
11012	Clearing land II-F	
11013	Clearing land III-F	
11021	Conservation 1 on land I-C	
11022	Conservation 1 on land II-C	
11023	Conservation 1 on land III-C	
11024	Conservation 1 on land IV-C	
11031	Conservation 2 on land II-C	x
11032	Conservation 2 on land III-C	x
11033	Conservation 2 on land IV-C	x
11034	Conservation 3 on land IV-C	x
11041	Pasture renovation land I-D	
11042	Pasture renovation land II-D	
11043	Pasture renovation land III-D	
11044	Pasture renovation land IV-D	
11045	Pasture renovation land IV-E	
11046	Pasture renovation land V-E	
11047	Pasture renovation land VI-E	
11048	Pasture renovation land VII-E	
11051	Reforestation land IV	x
11052	Reforestation land V	x
11053	Reforestation land VI	x
11054	Reforestation land VII	x
11055	Christmas trees on land VI	
11056	Christmas trees on land VII	
11061	Pasture to cropland land I-D	
11062	Pasture to cropland II-D	
11063	Pasture to cropland land III-D	
11064	Pasture to cropland land IV-D	
11066	Pasture on land I-D	
11067	Pasture on land II-D	
11068	Pasture on land III-D	
11069	Pasture on land IV-D	
11070	Pasture on land IV-E	

Table 25 continued.

Activity code no.	Description	Entry in objective function
11071	Pasture on land V-E	
11072	Pasture on land VI-E	
11073	Pasture on land VII-E	
11074	Pasture on land VI-F	
11075	Pasture on land VII-F	
11076	Pasture on land VI-G	
11077	Pasture on land VII-G	
11101	Continucus corn on land I-A	
11102	Corn--soybeans rotation on land I-A	
11103	CCCOMM rotation on land II-A	
11104	CCOMM rotation on land III-A	
11105	COMM rotation on land IV-A	
11106	Continuous corn on land I-B	
11107	Corn--Soybeans rotation on land I-B	
11108	CCCOMM rotation on land II-B	
11109	CCOMM rotation on land III-B	
11110	CCOMM rotation on land I-C	
11111	CCOMM rotation on land II-C	
11112	COMM rotation on land III-C	
11113	COMMMM rotation on land IV-C	
11114	Vegetables (beans) on land I-A	
11115	Vegetables (tomatoes) on land I-A	
11131	Harvest forest products on land I-F	x
11132	Harvest forest products on land II-F	x
11133	Harvest forest products on land III-F	x
11134	Harvest forest products on land IV-F	x
11135	Harvest forest products on land V-F	x
11136	Harvest forest products on land VI-F	x
11137	Harvest forest products on land VII-F	x
11141	Clear cut land I-F	
11142	Clear cut land II-F	
11143	Clear cut land III-F	
11144	Clear cut land IV-F	
11145	Clear cut land V-F	
11146	Clear cut land VI-F	
11147	Clear cut land VII-F	
11201	Swine production, technology 1	
11202	Swine production, technology 2	
11203	Swine production, technology 3	
11204	Beef production, technology 1	
11205	Beef production, technology 2	

Table 25 continued.

Activity code no.	Description	Entry in objective function
11206	Beef production, technology 3	
11207	Beef production, technology 4	
11208	Beef cows	
11209	Dairy production, grade B	
11210	Dairy production, grade A	
11211	Poultry production	
11251	Transfer land VI to forest	
11252	Transfer land VII to forest	
15111	Land I-A and VI-F to recreation use	
15112	Land I-A and VII-F to recreation use	
15113	Land II-A and VI-F to recreation use	
15114	Land II-A and VII-F to recreation use	
	Industry sector:	
12001	Meat products	
12002	Butter	
12003	Cheese	
12004	Condensed milk	
12005	Ice cream	
12006	Fluid milk	
12007	Canned vegetables	
12008	Frozen vegetables	
12009	Animal feeds	
12010	Corn milling	
12011	Bakery products	
12012	Soft drinks	
12013	Miscellaneous food products	
12014	Apparell	
12015	Logging	
12016	Sawmill products	
12017	Hardwood products	
12018	Millwork	
12019	Neneer and plywood	
12020	Prefab wood structures	
12021	Wood containers	
12022	Wood preserving	
12023	Wood furniture	
12024	Pulp mill products	

Table 25 continued.

Activity code no.	Description	Entry in objective function
12025	Paper mill products	
12026	Paperboard	
12027	Converted paper products	
12028	Paperboard containers	
12029	Newspapers	
12030	Book publishing	
12031	Commercial printing	
12032	Miscellaneous printing	
12033	Fertilizer	
12034	Miscellaneous chemical products	
12035	Plastic materials	
12036	Soaps and cleaners	
12037	Paint	
12038	Miscellaneous plastics	
12039	Leather tanning	
12040	Glass containers	
12041	Brick and tile	
12042	Leather goods	
12043	Ceramic tile	
12044	Clay structural products	
12045	Pottery products	
12046	Concrete blocks	
12047	Ready mixed concrete	
12048	Lime	
12049	Metal cans	
12050	Heating equipment	
12051	Fabricated steel	
12052	Metal doors	
12053	Sheet metal products	
12054	Screw machine products	
12055	Metal stampings	
12056	Hardware	
12057	Metal services	
12058	Miscellaneous wire products	
12059	Internal combustion engines	
12060	Farm machinery	
12061	Construction machinery	
12062	Special dies and tools	
12063	Pumps and compressors	
12064	Power transmission equipment	
12065	General industrial machinery	

Table 25 continued.

Activity code no.	Description	Entry in objective function
12066	Machine shop products	
12067	Office machinery	
12068	Service industry machines	
12069	Electrical measuring instruments	
12070	Switch gear	
12071	Electrical housewares	
12072	Wiring devices	
12073	Electronic components	
12074	Storage batteries	
12075	Truck trailers	
12076	Trailer coaches	
12077	Boat building	
12078	Temperature controls	
12079	Surgical equipment	
12080	Watches	
12081	Jewelry	
12082	Games and toys	
12083	Sporting goods	
12084	Pens and pencils	
12085	Artificial flowers	
12086	Buttons	
12087	Construction	
12088	Stone mining	
	Commercial sector:	
13031	Grocery stores	
13032	Restaurants	
13033	Furniture and appliance stores	
13034	Clothing and department stores	
13035	Variety, drug, and hardware stores	
13036	Auto sales and service	
13037	Medical service	
13038	Finance and legal service	
13039	Personal services	
13040	Miscellaneous services	
13041	Recreation services	
13043	Transportation services	
13045	Wholesale services	
13201	Agricultural equipment	
13202	Agricultural supplies	

Table 25 continued.

Activity code no.	Description	Entry in objective function
Public sector:		
14100	Public services	x
Recreation sector:		
15100	Camper tourism	
15200	Non-camper tourism	
15150	Convert land to recreation use	
Consumption sector:		
16000	Personal consumption	
16310	Transfer labor to agriculture sector	
16320	Transfer labor to industry sector	
16330	Transfer labor to commercial sector	
16340	Transfer labor to public sector	
16350	Transfer labor to recreation sector	
16325	Transfer labor to construction	
16335	Transfer labor to transportation	
16336	Transfer labor to personal services	
16338	Transfer labor to professions	
16351	Professional--technical labor transfer	
16352	Farm manager labor transfer	
16353	Proprietor labor transfer	
16354	Clerical labor transfer	
16355	Sales labor transfer	
16356	Craftsmen labor transfer	
16357	Operatives labor transfer	
16358	Service labor transfer	
16359	Farm labor transfer	
16360	Laborers transfer	
16361	Transportation labor transfer	
16362	Private household labor transfer	
16312	Educate high school to two year	x
16323	Educate two year to four year	x
16500	Import money	
11460	Transfer entrepreneural income from agriculture sector	

Table 25 continued.

Activity code no.	Description	Entry in objective function
12460	Transfer entrepreneural income from industry sector	
13460	Transfer entrepreneural income from commercial sector	
15460	Transfer entrepreneural income from recreation sector	
12450	Transfer wages and salaries from industry sector	
13450	Transfer wages and salaries from commercial sector	
14450	Transfer wages and salaries from public sector	
16400	Personal savings	
14950	Welfare activity	
14901	Taxation activity	
11820	Invest operating capital in agriculture sector	
12820	Invest operating capital in industry sector	
13820	Invest operating capital in commercial sector	
15820	Invest operating capital in recreation sector	
11470	Transfer capital to capital stock in agriculture (machinery)	x
11475	Transfer capital to capital stock in agriculture (buildings)	x
12470	Transfer capital to capital stock in industry	x
13470	Transfer capital to capital stock in commerce	x
15470	Transfer capital to capital stock in recreation	x
16610	Transfer capital from bank to general investment capital	
16900	Improved housing transfer	x
11480	Transfer unused capital stock to next period from agriculture (machinery)	
11481	Transfer unused capital stock to next period from agriculture (buildings)	
12480	Transfer unused capital stock to next period from industry	
13480	Transfer unused capital stock to next period from commerce	
16700	Transfer savings between time periods	

[1]Activities for first time period used as examples.

Two labor transfer activities are demonstrated in Table 26 which utilize labor of various occupations (denoted by labor a, b, and c) and provide labor to the five model sectors.[26] The model includes one such activity for each sector. Two capital transfer activities are also demonstrated. The first provides a transfer of general capital to the investment capital row from which capital investments are financed. Since capital stock is increased, an addition is made to the investment capital restraint of subsequent time periods and also to the objective function. The second capital transfer activity moves general capital to the operating capital restraint of a sector. From this restraint the various production activities obtain capital for operating expenses. One of each of these capital transfer activities is included in the model for each sector. The land drainage activity is illustrative of those which change the productivity of the land resource by an investment of capital. Land is thus removed from one resource classification and added to another in the current time period as well as all subsequent time periods.

A set of five production activities are demonstrated, one from each sector. Each utilizes quantities of land, labor, and capital and produces an output of either physical product or services. In some instances the transfer of output is internal to the sector, i.e., grain output used in livestock production. In all cases the output is added to the accounting rows (in the form of the Y coefficients) to allow analysis of output by sector. The production activities of the agriculture and industry sectors are not constrained by demands. The other sectors (commerce, recreation, and public) are constrained by equality rows in the model which prevents production from exceeding demand. The taxation activity provides financial support to the public sector. Consumption is provided for the area population by a consumption activity which creates demands for commercial services and public activities. Wages are demanded to finance the consumption. All residents of the area are provided for by the population equality row.

Two savings activities transfer entrepreneural incomes and

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[26]The sectors are indicated as follows: A--agriculture, I--industry, C--commerce, R--recreation, and P--public.

Table 26. Representation of the programming model.

			16310 Labor to ag.	16320 Labor to ind.	11470 Inv. cap. to ag.	12820 Opp. cap. to ind.	11001 Drain land	11101 Ag. prod.	12005 Ind. prod.	13031 Comm. act.	15100 Rec. act.	14100 Pub. act.	14901 Taxa-tion	16000 Con-sump-tion	16400 Sav. wages	11460 Sav. entr. inc.	16312 Edu-ca-tion	16700 Cap. tr.	Row type
19352	Labor a	B	A														-A		L
19353	Labor b	B		A															L
19360	Labor c	B		A													A		L
17310	Labor A		-A					A											E
17320	Labor I			-A					A										E
17330	Labor C									A									E
17340	Labor R										A								E
17350	Labor P											A							E
17100	Gen.cap.	B			A	A							A		-A	-A	A	A	L
17501	Inv. cap.A	B			-A		A	A											L
17502	Inv.cap.I	B							A										L
17503	Inv.cap.C	B								A									L

Table 26 continued.

			16310 Labor to ag.	16320 Labor to ind.	11470 Inv. cap. to ag.	12820 Opp. cap. to ind.	11001 Drain land	11101 Ag. prod.	12005 Ind. prod.	13031 Comm. act.	15100 Rec. act.	14100 Pub. act.	14901 Taxation	16000 Consumption	16400 Sav. wages	11460 Sav. entr. inc.	16312 Education	16700 Cap. tr.	Row type
17504	Inv.cap.R	B									A								L
19701	Op.cap.A							A											L
19702	Op.cap.I					-A			A										L
19703	Op.cap.C									A									L
19704	Op.cap.R										A								L
19705	Op.cap.P											A	-A						E
17011	Land I	B					-A	A											L
17021	Land II	B			A														L
10260	Wages								-A	-A		-A		A	A				L
10250	Entr.inc.							-A	-A	-A	-A					A			L
19031	Comm.serv.1							A	A	-A	A	A		A					E

Table 26 continued.

			16310 Labor to ag.	16320 Labor to ind.	11470 Inv. cap. to ag.	12820 Opp. cap. to ind.	11001 Drain land	11101 Ag. prod.	12005 Ind. prod.	13031 Comm. act.	15100 Rec. act.	14100 Pub. act.	14901 Taxation	16000 Consumption	16400 Sav. wages	11460 Sav. entr. ind.	16312 Education	16700 Cap. tr.	Row type
14100	Pub.transt.											-A		A					E
19100	Rec.dem.										-A								E
10960	Popn.	B												A					E
19101	Output A							-Y											N
19102	Output I								-Y										N
19103	Output C									-Y									N
19104	Output R										-Y								N
27011	Land I q	B					-T												L
27021	Land II	B					T												L
27501	Inv.cap.A	B			-T														L
29352	Labor a	B												-T					

Table 26 continued.

			16310 Labor to ag.	16320 Labor to ind.	11470 Inv. cap. to ag.	12820 Opp. cap. to ind.	11001 Drain land	11101 Ag. prod.	12005 Ind. prod.	13031 Comm. act.	15100 Rec. act.	14100 Pub. act.	14901 Taxation	16000 Consumption	16400 Sav. wages	11460 Sav. entr. inc.	16312 Education	16700 Cap. tr.	Row type
29360	Labor c	B															T		
27100	Gen.cap.										-T	-T					-T		L
Objective function				Z						Z							Z	(Z)[a]	

[a]Appears only in capital transfer activity of last time period.

wages (in excess of consumption) into the general capital rows of the current and next time periods for reinvestment. The division of savings between the two time periods was discussed in an earlier section. An education activity is illustrated which transfers labor from one occupational class to another. Appropriate transfers are also made in subsequent time periods, and an objective function entry is made which represents the addition to human investment capital. A capital transfer activity is included to transfer unused capital from one time period to the next. In the last time period, any unused capital is added to the objective function to eliminate unnecessary and unprofitable capital investments.

Objective Function

Entries in the objective function reflect additions to investment capital financed by production over the nine years of the model. These additions are discounted to the present value at the end of the time frame. The following equation was utilized to determine the objective function entry where V is the objective function entry, I is the actual investment amount, r is the discount rate, and n is years remaining to end of 9-year time frame:

$$V = \frac{I}{(1+r)^n}$$

Investments made in early time period add less to the objective function value but allow a longer period of productivity.

SOLUTION RESULTS

The solution summary in this section is presented as an indication of the information available from the development model. The actual numerical data is of interest mainly to those directly involved or interested in northeast Iowa.

Four additional assumptions were made to obtain the model solution. First, population of the area was held constant over

the three time periods. Second, half of the liquid capital resources were held as "bank deposits." These deposits could not be invested in production activities but did earn an interest payment. Third, livestock production was required to be greater than or equal to the least annual production of the past ten years. Fourth, minimum annual recreation demands were set equal to those predicted by the Iowa State University Cooperative Extension Service [14]. Maximum demands were set at the same number plus 10 percent.

Production Activities and Resource Utilization

Production in each sector will be illustrated and discussed in order for each of the three model time periods.

Agriculture sector

Agricultural production in the solution is summarized in Table 27. It is noted that conservation and drainage activities receive an early priority in the base solution. Livestock enters the solution at the minimum levels with the exception of poultry, which trends downward through the three time periods.

Oats and meadow acreage remain constant due to the demands for forage created by livestock production. Corn and soybean acreage trends downward as Christmas tree production trends upward. Renovation of pastures has a high priority and is accomplished in the first time period.

The land use pattern for the first time period of the base model is summarized in Table 28. The land in disuse of Classes II and III is that requiring an investment in drainage (sub-class B). It is noted that of the 96,806 acres in land Class II-B, only 16,048 are drained. Land of Class III-B is not used for crops. Contour cropping (conservation I) is accomplished on all land of sub-class C. Strip cropping and terracing (conservation II) allows intensive use of land Class II. Level terracing (conservation III) allows a CCOMM rotation on land Class III.

Land use patterns in the second and third time periods are

Table 27. Agricultural production in model solution.

Item	Annual production by time periods		
	I	II	III
Livestock			
Hogs (head)	62,623	62,623	62,623
Beef (head)	85,169	85,169	85,169
Beef cows (head)	63,294	63,294	63,294
Dairy cows (head)	101,922	101,922	101,922
Poultry (turkey equivalents)	27,090	26,446	26,005
Rotation crops			
Corn (acres)	544,633	504,210	466,477
Soybeans (acres)	372,331	346,764	294,175
Oats (acres)	100,836	100,836	100,836
Meadow (acres)	201,672	201,672	201,672
Non-rotation crops			
Renovated permanent pasture (acres)	287,652	287,652	287,652
Harvest forest products (acres)	307,018	162,020	132,636
Christmas tree plantings (acres)	49,775	103,886	110,064
Clear cut forest (acres)	49,775	86,603	87,779
Conservation activities			
Conservation I (acres)	778,226	0	0
Conservation II (acres)	526,927	0	0
Conservation III (acres)	146,296	0	0
Land drainage (acres)	28,624	0	0
Land clearing (acres)	0	0	0

Table 28. Land use of the first time period of model solution.

Practices and land use	Land class						
	I	II	III	IV	V	VI	VII
Conservation activities (acres)							
Drainage (sub-class)	12,576	16,048	--	--	--	--	--
Conservation I	855	305,533	378,914	92,924	--	--	--
Conservation II	--	526,927	--	--	--	--	--
Conservation III	--	--	146,296	--	--	--	--
Crops (acres)							
Corn-soybeans	71,512	526,927	146,223	--	--	--	--
CCOMM rotation	--	--	353,830	--	--	--	--
COMM rotation	--	--	--	120,280	--	--	--
Rotation pasture	20,177	55,470	68,181	34,966	19,200	50,408	39,250
Forest	7,044	17,110	57,024	43,042	8,416	29,159	145,223
Christmas trees	--	--	--	--	--	--	49,775
Total land use (acres)	98,733	599,507	625,288	198,288	27,616	79,567	234,248
Land in disuse (not cropped, acres)	0	80,758	527	0	0	22,285	17,357

similar. The primary change occurs in (a) the acreage of the corn-soybeans rotation on land Class III and (b) the acreage of Christmas tree plantings on land Class VI and VII.

The resources used for agricultural activities are illustrated in Table 29. Comparing the land requirements with the land availability indicated in Table 7, it is noted that land disuse (not used for crops) increases from 120,999 acres in time period I to 392,404 acres in time period III. Labor requirements increase over three time periods. The labor-intensive Christmas tree production activity causes an increase in the labor requirements despite the reduction in row crops. Over one-third of the total labor force is employed in agriculture.

Table 29. Agriculture sector resource use in model solution.

Item	Resources used by time periods		
	I	II	III
Labor (man-years)	13,295	13,524	14,562
Land (acres)			
Capability class I-IV	1,521,786	1,470,652	1,364,474
Capability class V-VII	341,431	250,544	277,338
Total (acres)	1,863,217	1,721,196	1,591,812
Capital (000$)			
Operating capital	256,368	190,300	194,783
New capital investments	46,000	46,000	45,269

Industry sector

Industrial activities were allowed to enter the solution at quantities ranging from zero to 400 employee units in the first time period. The upper limit was reduced to 200 additional employee units in the subsequent two time periods. This upper limit is set to force industrial diversification.

Industrial production in the solution is illustrated in Table 30 indicating man-year units of industrial activity as well as value of product for each of the three time periods. It is noted that employment in four industrial activities is at the upper limit of 400 units in the first time period. The logging activity increases by 200 units in the second time period.

Table 30. Industrial production in model solution.

Item		Units of production in time periods		
		I	II	III
Activity name and code number			(man years)	
Logging	12015	400	600	600
Paperboard	12026	400	400	400
Soaps & cleaners	12036	400	400	400
Lime	12048	400	400	400
Metal cans	12049	97	97	97
Total		1,697	1,897	1,897
Value of product			(000$)	
Logging		26,299	41,816	41,816
Paperboard		55,967	55,967	55,967
Soaps & cleaners		88,175	88,175	88,175
Lime		36,371	36,371	36,371
Metal cans		13,153	13,153	13,153
Total		219,965	235,482	235,482

Resource use in the industrial sector is summarized in Table 31. An excess amount of capital stock exists in the first time period, and almost $15 million goes unused. In the second period, however, the capital stock is entirely used, and in the third time period an additional investment of $20 million is required. Operating capital of almost $90 million is required for industrial production in the first time period. The requirement is increased to over $97 million in the second and third time periods.

Table 31. Model solution of resource use in industrial sector.

Item	Time periods		
	I	II	III
Labor employed (man-years)	1,697	1,897	1,897
Capital used (000$)			
Operating capital	89,613	97,157	97,157
New capital investments	0	0	0
Capital stock not used	14,809	0	0

Commerce sector

Employment in each of the 15 commercial activities for each of the three time periods is indicated in Table 32. Employment remains relatively constant over the three time periods for all commercial services except those serving agriculture. The downward employment trend in agricultural supplies is greater than in agricultural machinery and equipment. This employment trend is consistent with the downward trend of corn and soybean production indicated above in the discussion of the agriculture sector. However, as also indicated the movement away from crops and toward the harvest of forest products maintains a relatively stronger demand for agricultural machinery and equipment.

Resource use by the commercial sector is summarized in Table 33. Excess capital stock in the first time period is indicated in the amount of $108,000. The capital stock supply is in balance with the demand in the second time period, and an investment of almost $30 million is required in the third time period.

Public sector

Employment in the public sector is 4,033 man-years for each of the three time periods. Tax payments to support the public

Table 32. Model solution of commercial sector production in man-year units.

Item		Production by time periods I	II	III
Activity name and code number			Units in man-years	
Grocery stores	13031	1,314	1,311	1,314
Restaurants	13032	1,817	1,807	1,818
Furniture & appliances	13033	594	594	594
Clothing & department	13034	1,458	1,456	1,458
Variety, drug, & hardware	13035	932	925	932
Auto, sales & service	13036	1,075	1,073	1,076
Building materials	13037	172	172	172
Medical services	13038	104	104	104
Financial and legal	13039	743	743	743
Personal services	13040	912	907	913
Miscellaneous services	13041	1,370	1,363	1,371
Transportation services	13043	47	47	47
Wholesale services	13045	48	48	46
Agric. machinery & equipment	13201	169	169	165
Agricultural supplies	13202	768	737	708
Totals		11,523	11,456	11,461

Table 33. Resource use in commercial sector of model solution.

Item	Resource use in time periods I	II	III
Labor (man-years)	11,523	11,456	11,461
Captial (000$)			
Operating capital	283,015	280,426	275,838
New capital investments	0	0	29,972
Capital stock not used	108	0	0

sector are $50,410,700 per year.

Recreation sector

Activity in the recreation sector is summarized in Table 34. Both camper and non-camper recreation activities enter the solution at the upper numerical limits in the first time period but at the lower limits of the specific period in the two subsequent periods. (See earlier discussion of upper and lower limits.) This trend causes a significant decrease in total expenditures made by tourists in the second time period. This decrease is reflected in the demands on commercial services indicated in Table 32.

Table 34. Three-year total recreation sector activities in model solution.

Item	Time periods		
	I	II	III
Campers (visitor nights)	1,205,600	1,156,000	1,213,998
Non-campers (visitor nights)	301,400	289,000	303,558
Total expenditures (000$)	41,426	31,501	41,707

Resource use for the recreation sector is summarized in Table 35. Indirect labor demands are included to indicate the effects of the recreation sector on the commercial sector. A capital investment of $148,000 is required to increase campground capacity to meet the demands of the predicted increase in tourism.

Consumption sector

The consumption demand created by the 95,672 persons residing in Upper Explorerland is $287,016,000 per year. This demand translates to $861,048,000 for each of the three-year time periods. The taxation requirement to support public activities is $151,232 for each of the time periods.

Table 35. Resource use in recreation sector of model solution.

Item	Time periods		
	I	II	III
Labor (man-years)			
Campground managers	20	19	21
Indirect (commercial employment created)	774	742	781
Land (acres)	205	205	205
Capital (000$)			
Operating capital	301	289	303
New capital investments	148	0	0

Table 36 provides a summary of the net earnings produced by each of the five production sectors for the base model. It is noted that earnings increase for the agriculture and industry sectors but decrease for the commerce sector. The decrease in commercial demands is caused primarily by the reduction in row crop production in the agriculture sector.

The total amount of capital available for reinvestment also is indicated as significant in Table 36. Although a decline in reinvestment monies is indicated in the second time period, the third period has a significant increase.

Miscellaneous findings

Table 37 indicates several miscellaneous findings of the base model. Two-year vocational training enters the solution the first and second years. Four-year, college-level education is found to be zero for all three time periods.

Over 5,000 workers are unemployed in the first time period. The unemployment rate drops to under 4,000 in the last period. This level of unemployment creates a significant demand on welfare transfers. It is noted, however, that what appears to be unemployment can more accurately be defined as underemployment. Labor

Table 36. Summary of consumption sector for model solution.

Item	Time periods		
	I	II	III
Income produced (000$)			
Agriculture sector	765,289	744,040	829,065
Industry sector	85,383	88,818	88,818
Commerce sector	521,301	511,720	508,932
Public sector	60,493	60,779	60,709
Recreation sector	603	578	607
Total	1,433,069	1,405,935	1,488,131
Consumption demands (000$)	861,048	861,048	861,048
Taxation for public activities (000$)	151,232	151,232	151,232
Taxation available for reinvestment (000$)	420,789	393,655	475,851

resources were defined in terms of man-years.[27] The model was capable of ascertaining only that a surplus of labor was available. Table 36 indicated that total net income was in excess of demands for the minimum annual per capita consumption expenditures and taxation requirements. A sizeable quantity of capital was borrowed from outside sources in the first time period.

Objective function value

The objective function chosen for the model used in this study was that of maximization of additions to investment capital. For the base model the net increase in investment capital was $411,679,785. This amount represents a 199.3 percent increase in non-liquid capital resources.

[27] A man-year is defined as 50 forty-hour weeks of labor.

Table 37. Miscellaneous findings in solution.

Item	Time periods		
	I	II	III
Vocational training (man-years)	250	61	8
College degree (man-years)	0	0	0
Unemployed workers (man-years)	5,162	4,801	3,756
Capital borrowed (000$)	1,356,165	0	0[a]
Welfare transfers (000$)	124,038	115,362	92,358

[a]Capital borrowing not allowed in last time period.

Solution Analysis

A linear programming solution provides the optimum plan for utilization of the available resources to maximize the objective function subject to the stated restraints in resources and other conditions. Any deviation from the optimal plan results in a decrease in the objective function value. Land, labor, and capital were defined as the primary resources in this study. In the base model solution, capital is the only resource used to the limit of its availability. Some quantities of land and labor are not used, thus implying a surplus of these two resources relative to the limited capital available and the nature of the model's objective function.

Data are provided for other information forthcoming by the linear programming procedure. This information includes (a) reduced cost, (b) shadow prices, (c) range, and (d) trancol analyses. The analysis indicates the amount of the reduction in the objective function value resulting from any given change. A measure of the sensitivity of the solution is also provided and indicates the range of resource availability or activity levels over which this reduction is relevant.

The interpretation of results provided by the solution must be conducted with judgment. The typical linear programming model either maximizes or minimizes relevant goals. The typical analysis,

for example, relates information concerning the increases in profits or decreases in cost resulting from deviations from the optimal pattern of resource use or activity levels.

The model used in this study maximizes additions to investment capital, subject to resources available and certain specified goals of development in the Upper Explorerland area. Therefore, the solution analysis also can indicate decreases in investment capital accumulation resulting from deviations from the optimal solution values.

Capital

The liquid capital resources are utilized completely in all three time periods. Borrowing from outside sources was allowed in the first and second time periods only, and all monies borrowed were required to be repaid in the next time period. An annual rate of interest of 5 percent was charged on outside borrowing. This interest charge also placed a restriction on the rate of investment capital accumulation. In effect the rate of investment capital accumulation is set equal to the annual interest rate on outside borrowings.

Over 1 and 1/3 billion dollars was borrowed in the first time period. The analysis indicates a marginal contribution to investment capital of 4.7 percent for capital made available up to $1.4 billion. Thus investment capital was increasing at a rate of 4.7 percent when capital borrowing was terminated.

Capital investments were limited in the model to a maximum of one-third the original capital stock of each sector per time period. This maximum was not restrictive in the industrial or commercial sector where quantities of capital stock were not utilized in the first time period. The recreation sector also was not affected by this restraint. The agriculture sector was, however, restrained by the limitation. Fifteen million dollars was the maximum new investment allowed for agricultural buildings in each time period. Investment in agricultural buildings would provide increases in investment capital of $14.18 per dollar for an additional $2,292,000 in time period one; $9.00 per dollar for an additional $1,567,000 in time period two; and $4.37 per dollar

for an additional $3,418,000 in the third time period.

Investments in new agricultural machinery were limited to $31 million for each time period. Additional investments would provide increases in the objective function value of $2.39 per dollar for $3,994,000 and $1.34 per dollar for $1,803,000 for the first and second time periods, respectively. Additional investments in agricultural machinery in the third time period were not indicated.

The capital restraints were therefore indicated to be more restrictive to the agriculture sector than any other sector. Livestock production in particular was restrained by the availability of capital. Livestock was produced in all three time periods by labor-intensive methods.

The industrial sector was restrained by the availability of capital for operating expenses. A number of industrial activities were indicated to be profitable, and capital stock was available to allow increased industrial activity. However, the operating capital was not available to cover the expense of purchasing raw materials and hiring labor.

The capital restraints were not as restrictive in the second and third time periods, allowing increased industrial employment and revisions in the pattern of agricultural production.

Labor

Labor is available in Upper Explorerland in excess of employment opportunities, and underemployment prevails. Total incomes are sufficient to provide for consumption by all residents. The unemployment rate (i.e., actually underemployment) decreases from over 5,000 man-years in the first time period to less than 4,000 in the third time period. Labor utilization in the first time period is 7,177 with high school training, 22,182 with post-high school training, and 1,148 with college degrees. The surplus labor in each category is 349, 2907, and 1906 man-years, respectively. Generally, of course, persons with college degrees are expected to be more mobile than the rest of the population. Aside from restraints on age and health, this surplus labor force

would be expected to migrate from the region.

The base model solution is quite sensitive with regard to labor utilization. The analysis indicates that increases in labor utilization result in decreases in investment capital accumulation of only $1.52 and $4.10 per man-year for high school trained and post-high school trained workers, respectively. These negative marginal value products are relevant for increases in employment up to 7,231 high school trained workers and 22,490 post-high school trained workers. The decrease in objective function value is much greater for reductions in labor usage. High school trained workers cause a reduction of $43.34 per man-year in objective function attainment down to 6,863 workers. Post-high school trained workers cause the objective function to decrease by $983.47 per man-year down to 21,282 workers. College degree workers cause changes in the objective function value of $74,311.99 per man-year for increases to 4,915 workers and $254.86 per man-year for decreases in worker availability to 1,175. It is evident that the commercial demands created by the excess labor supply largely suppress the negative effect caused by this excess supply. Each unemployed worker creates a direct welfare transfer of $8,010 per year, much of which could be utilized for investment under a full employment solution. However, the cost is reduced to $2,391 per unemployed worker due to the multiplier effect.

Land

Almost all land, Classes I through IV, is utilized in time period one. Sizeable quantities of land needing drainage (subclass B) are unused. The cost of drainage is $200 per acre, and crop yields are low on undrained land. Utilization, if increased, of land Class II-B decreases the objective function value by $11.79 per acre and $26.30 if decreased from the optimum level of 16,048 acres. Land of Classes V through VII is not utilized for crops but is used for pasture, forest, and Christmas tree production.

Additional land of certain classes is shown to be of high value. An additional 16,000 acres of land Class I-A could be utilized with each acre available in the first time period, in-

creasing investment capital by $81.84. Other land classes which were utilized at the upper limit had lower values associated down to $1.52 per acre for land Class II-D. The analysis indicates that, although capital restrictions were quite severe in the agricultural sector, more land in the better-quality classes would have provided significant increases in the objective function value. In the second and third time periods, row crop production declines somewhat as Christmas tree production increases. This change in land use occurs as capital becomes less restrictive in the later time periods. Forest products are harvested on a significant amount of forested land. The large amount of forest products harvested in the first time period reflects a resource that has been largely neglected in past years.

Production activities

Four industrial activities are included in the solution at the upper limit of 400 man-year units in the first time period. These activities are logging, paperboard manufacture, soap and cleaners manufacture, and limestone production. Further increases in each of these industrial activities could provide increases in investment capital. Each additional man-year unit of the logging activity, up to a total of 403, would provide an increase of $77,864 to the objective function. Additional man-year units of paperboard, soaps and cleaners, and lime manufacture would provide increases in the objective function value of $27,584, $37,730, and $5,970 up to 496, 498, and 495 man-year units, respectively.

Additional investments in the industrial sector in the second time period are suggested only in the logging activity. A per unit increase in investment capital of $36,482 is indicated for an additional 204 man-year units. The third time period includes no industrial expansion activities with positive marginal value products.

The recreation sector presents an interesting situation. Recreation activities are included in the first time period at the upper limit of the solution. The marginal increase in investment capital is $6.06 for a camper visitor-night and $12.47 for a non-camper visitor-night. These values apply up to 3,792,708

camper and 1,602,243 non-camper visitor-nights. However, in subsequent time periods the activities are at lower limit levels, and the marginal additions to investment capital are negative. The values are -$8.33 and -$17.13 per visitor-night for campers and non-campers in time period two. These values are relevant in a range of 447,596 to 1,220,373 visitor-nights for campers and 0 to 321,199 visitor-nights for non-campers. For time period three, the values are -$21.02 and -$42.65 for campers and non-camper tourists. The values are relevant for ranges of 1,149,622 to 2,065,687 visitor-nights for campers and 271,357 to 729,563 visitor-nights for non-campers.

The analysis indicates that, in the first time period when capital is restrictive, the low capital requirements of the recreation sector provide attractive investment opportunities. In later time periods when capital is less restrictive, the comparative advantage of tourism is diminished until in the last time period one visitor-night by a non-camper tourist reduces the objective function value by more than -$42.

Overall Pattern of Model Solution

Resources are available in Upper Explorerland to provide for the achievement of the ten rural development goals as well as to increase investment capital to 199 percent. The agricultural sector provides the primary basis for area development. Fifty-four percent of the net income produced by the area is derived from the agricultural sector as well as 39 percent of the additions to investment capital.

Harvesting forest products and raising Christmas trees are indicated to be of high value to area development. Northeast Iowa could possibly become a major Christmas tree producing area in the United States. The close proximity of urban areas, the excess supply of labor, and the soil resources and topography combine to make Christmas tree production an attractive alternative.

With over $14 million of capital stock in disuse in the first time period, the industrial sector is in need of additional operating capital. Almost 23 percent of the original capital stock is not used in the first time period. This capital stock,

if utilized, would employ approximately 400 more workers and increase net income from the industrial sector by over $200 million in each time period.

Capital resource availability provides an interesting situation in Upper Explorerland. Numerous investment possibilities are present in the area's economy which have positive net profits when calculated on a cost-return basis. The additions to investment capital are small for these possibilities, however. The solution analysis indicates that the next incremental quantity of capital made available would increase investment capital by 4.7 percent.[28] All capital borrowing is accomplished in the first time period, indicating the need for significant quantities of capital early in the developmental time frame.

Significant quantities of labor are not utilized due to the lack of productive activities as discussed above. Some of the land resources and capital stock resources are likewise delegated to less-intensive uses.

In conclusion the base model indicates that marginal additions to the objective function are costly in terms of resource use. The Upper Explorerland area is over populated and under capitalized relative to its other resources.

SUMMARY

The study was designed primarily to use a linear programming model in evaluating optimal strategies in rural community development. The work proceeded through four distinct phases: (a) developing a concept of rural development which could be used in a linear programming framework, (b) defining the resources and possible production and consumption activities consistent with the study area, (c) building a linear programming model consistent with (a) and (b) above which was capable of providing information useful to development planners, and (d) obtaining and analyzing solutions to the model. Land, labor, and capital were considered

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[28] A dollar added to the economy would raise the objective function value to 4.7¢.

as the basic resources. The land resource was divided into seven use-capability classes and seven cropping-pattern categories. The labor force was classified into three training levels and 12 occupational categories. The two capital classes defined were capital stock and liquid capital.

A dynamic linear programming model was developed to analyze the alternative investment possibilities of a multi-county area with a goal of rural community development. A five-county area of northeast Iowa served for the pilot study.

The production-consumption economy was divided into six sectors; agriculture, industry, commerce, recreation-tourism, public, and consumption. The agriculture and industry sectors were considered to operate in perfect competition, whereas the other sectors enter the model solution at levels which satisfy demands endogenously created. A set of 10 developmental goals was defined and entered into the model as minimum restraints. The objective function of the linear programming model was the maximization of additions to investment capital subject to the restraints and the supplies of land, labor, and capital in the area.

The time frame of the dynamic model was three 3-year periods totaling nine years. Solutions indicating optimal production, service, and consumption activity levels and resource utilization were obtained for each of the three time periods. Thus, the model provides information regarding the timeliness of optimal investments. The study explored the usefulness of the analytical procedures of modern linear programming models. These procedures were (a) shadow price analysis, (b) reduced cost analysis, (c) range analysis, and (d) trancol analysis.

The solution summary indicates the importance of the agricultural sector with significant capital investments made in land drainage and conservation practices. Of the total net income produced in the area during the nine years considered by the model, 54 percent was derived from the agricultural sector. Likewise, 39 percent of the additions to investment capital were provided by agriculture. Capital was the limiting resource for area development. This shortage creates unemployment or underemployment of sizeable quantities of labor. Optimal investment

for the area would call for land drainage, increased livestock production, a considerable increase in recreation and forestry, Christmas tree production, and maximum expansion (allowed by capital and other restraints) of paperboard, soaps, and cleaners. Employment and capital investment in the service or commercial sector of the area would need only modest expansion due to existing underemployment and related factors. Unemployment and (or) underemployment in the area would decrease considerably in the optimum plan. Capital availability as considered in the model is the restraining resource relative to land and labor.

Solutions obtained from the linear programming model provide specific information in regard to production and consumption activities in each of the 3-year time periods. In the agricultural sector, optimum levels of land drainage, conservation, forest production, crop production, and livestock production were defined and are detailed in the text. Levels of industrial production were provided in terms of man-years of activity. Recreation-tourist demands were translated into man-year units of service and are indicated numerically in the text. Commercial and public activities were derived from demands created by the area population. Information was derived from the solution indicating quantities of each resource class utilized in specific economic sectors of the model. The quantity of resources available in excess of demands also was provided for each of the three time periods.

The linear programming model developed in this study was not intended to be the optimal mathematical approach to the problems of rural development. A number of factors important to rural development planning were encountered during the exercise. First, it is evident that mathematical programming models can provide important inputs to developmental planning. Linear programming models in particular provide analytical information not required for other mathematical models. This type of information should prove to be valuable to developmental planners and community leaders in multi-county areas.

The importance and reliability of a linear programming solution depends on the data utilized to develop resource restraints and activity coefficients. One objective of the study was to utilize existing data in the development of the model. Resource data for multi-county areas is much more available than definite

coefficients for productive and consumptive activities. Resource requirements and output data are more readily available for agricultural production activities than for activities of the industrial or commercial sectors. The data problem makes geographically accurate and technically useful programming models costly both in terms of financial and time requirements.

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