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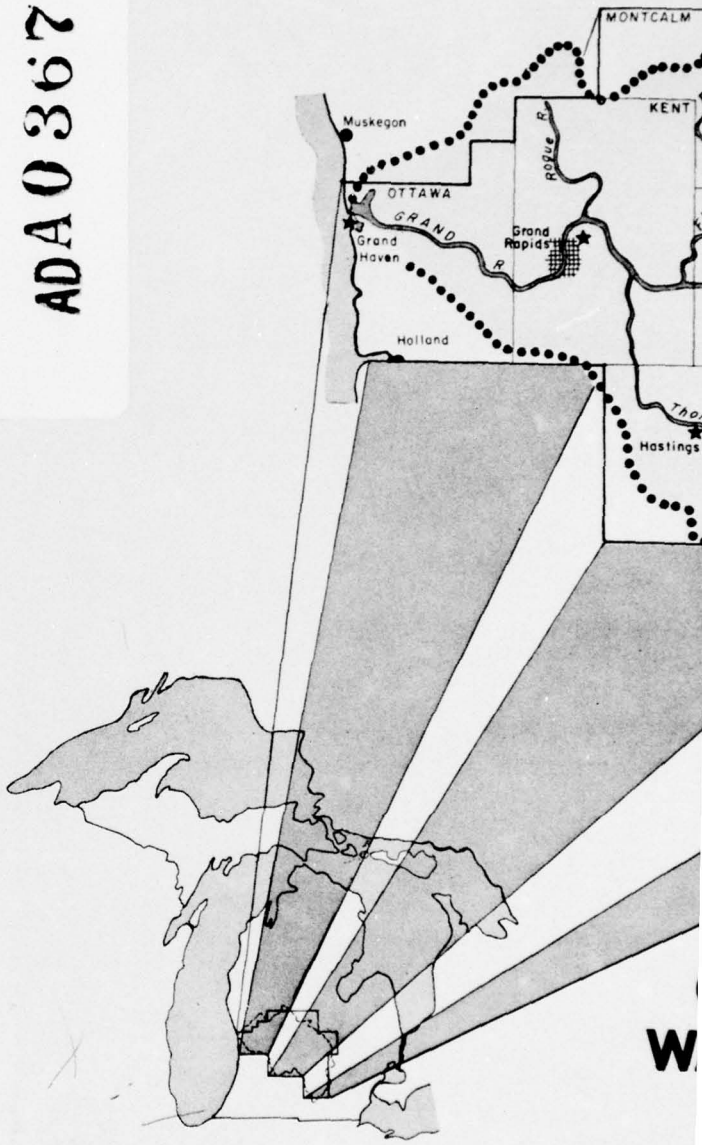

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VOLUME I

APPENDIX O — ECONOMI

Prepared Under Superv
GRAND RIVER BASIN COORDIN
Chairmanship: U. S. Army Engir
May 1970

DEPARTMENT OF THE ARMY
DETROIT DISTRICT, CORPS OF ENGINEERS
P.O BOX 1027
DETROIT, MICHIGAN 48231

PREFACE

This Economic Base Study, Grand River Basin, Michigan is part of a comprehensive study of the water and related land resources of the Grand River basin. The comprehensive study is directed by the Grand River Basin Coordinating Committee, composed of representatives of the State of Michigan; the Federal Power Commission; and the Departments of Agriculture; the Army; Commerce; the Interior; and Health, Education, and Welfare. The comprehensive study's main report will be published in about four years.

This publication is divided into four parts. Part I - "Population Growth and General Economic Development" - summarizes a Battelle Memorial Institute projective study of population and employment. Part II - "Electrical Energy Production and Requirements" - prepared by the Federal Power Commission, provides projections of power resources and demands. Part III - "Mineral Production and Reserves" - prepared by the Bureau of Mines and the Corps of Engineers, provides projections of the mining industry. Part IV - "Agricultural Activity in the Grand River Basin, 1970-2020: A Projective Study " - prepared by the Economic Research Service, Department of Agriculture, provides projections of agricultural production and land use.

Projections of population, employment, production, and land use are subject to margins of uncertainty. The reliability of projections is affected by the timespan of the projections, by the size of the area, by the level of disaggregation of economic activity attempted in the projections, by the volume of economic activity in the area, by the degree of diversification of the area's economy, and by the availability and reliability of the historical data for the area.

Many persons contributed to the economic base study and their support is gratefully acknowledged. A list of major contributors is provided in the Acknowledgements.

Edward C. Bruce

EDWARD C. BRUCE
Colonel, Corps of Engineers
District Engineer
Chairman, Grand River Basin
Coordinating Committee

Attachment
Acknowledgements

GRAND RIVER BASIN

MICHIGAN

COMPREHENSIVE

WATER RESOURCES

STUDY

PART I	Population Growth and General Economic Development
PART II	Electric Energy Production and Requirements
PART III	Mineral Production and Reserves
PART IV	Agricultural Activity in the Grand River Basin, 1970 - 2020: A Projective Study

VOLUME X

APPENDIX O - ECONOMIC BASE STUDY

JANUARY 1966

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GRAND RIVER BASIN COORDINATING COMMITTEE

P. O. BOX 1027
DETROIT, MICHIGAN 48231

Department of the Army
Chairmanship

Department of Agriculture

Department of Commerce

Department of Health,
Education & Welfare

Department of the Interior

Department of Transportation

Federal Power Commission

Great Lakes Basin Commission

State of Michigan

FOREWORD TO THE SECOND PUBLICATION

Five years ago, in January 1966, Appendix O (Economic Base Study) of the Grand River Basin Comprehensive Planning Study was first published. Since that time, data from Appendix O has been used to calculate projected needs for water and related land resources needs in the basin.

Some of the national projections contained herein would be modified somewhat if the study were to be redone today. Most of the modifications, however, would be applied to long-term projections (for the year 2000 and after).

If the study were to be redone, however, the relationship between the region and the Nation would have to be re-analyzed, and there is no assurance that the modifications in national projections would be paralleled by proportionate modifications in the regional projections.

Finally, if the regional projections were modified, the modifications would apply primarily to long-term projections, and would not significantly affect either the calculations of needs or the recommendations for basin development in the pre-2000 time period.

The short-term regional projections, which are the significant projections for plan formulation, appear to be accurate enough for study purposes. For example, the projected 1970 population of 1,272,100 persons in the study area compares with the actual census count of 1,275,627.

The Coordinating Committee has therefore decided to republish the economic base study herewith in its original form.

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MAR 10 1977
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MYRON D. SNOKE
Colonel, Corps of Engineers
Chairman

ACKNOWLEDGEMENTS

Personnel participated under various authorities as follows:

ECONOMIC BASE STUDY INFORMAL ADVISORY BOARD. The Informal Advisory Board was a subcommittee of the Grand River Basin Coordinating Committee, which was responsible for the overall coordination of the comprehensive study efforts. The Board was established in October 1963 when each Coordinating Committee member designated a representative to the Informal Advisory Board. The Board held ten official meetings, coordinated and reviewed all economic base study efforts, and provided advice and guidance to Battelle Memorial Institute personnel, the Corps of Engineers, and other participating agencies. Membership, assistance, and participation were as follows:

Major Governmental Unit Represented	Member	Assistance
State of Michigan	Dr. P.A. Herbert	Mr. L. Bronder
Agriculture	Mr. M.L. Cotner	Mr. J. Hostetler
Army	Mr. P. McCallister	Mr. T.E. Odle
Commerce	Mr. H. Krashen	
Federal Power Commission	Mr. O. Haukedahl	
Health, Education, & Welfare	Mr. W.J. Schuck	
Interior	Mr. H.C. Jordahl,Jr.	Mr. D.F. Klyce

In addition, informal participation in Board activities was provided by Mr. H.E. Olson of the U.S. Army Engineer Division, North Central, and Mr. S.C. Stearn of the Michigan Employment Security Commission.

PART I. a. Contract Administration by U.S. Army Engineer District, Detroit. Responsibility for progress on the contract with Battelle Memorial Institute was vested in the Project Engineer, Mr. P. McCallister, who was assisted by Messrs. C. Argiroff and T.E. Odle.

b. Contract Performance by Battelle Memorial Institute. Members of the Institute's staff who provided major contributions to PART I were Mr. R. Craig, Mr. J.W. Duncan, Dr. W.H. Fisher, Mr. G.W. James, Mr. J.M. Jennings, Dr. R.J. Lund, Mr. P. Max, and Mr. D.C. Sweet.

PART II. Mr. O. Haukedahl represented the Federal Power Commission in all discussions on PART II.

PART III. Bureau of Mines. Mr. D.F. Klyce was the major contributor.

Corps of Engineers. Mr. T.E. Odle was the major contributor.

PART IV. Mr. J.E. Hostetler performed the principal research for the Economic Research Service's contribution. He was assisted in the research and report writing by Mr. M.L. Cotner.

The participation of all of these persons, and others who have assisted, is gratefully acknowledged.

(6)

GRAND RIVER, MICHIGAN COMPREHENSIVE BASIN STUDY. Volume X. APPENDIX O. ECONOMIC-BASE STUDY.

PART I

POPULATION GROWTH AND GENERAL ECONOMIC DEVELOPMENT

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January 22, 1966

Colonel Edward C. Bruce
District Engineer
U. S. Army Engineer District, Detroit
150 Michigan Avenue
Detroit, Michigan 48231

Dear Colonel Bruce:

Reference is made to Contract No. DA-20-064-CIVENG-64-26, dated 27 September 1963, "An Economic-Base Study – Grand River Basin Service Area".

We are pleased to submit herewith 100 copies of our final report as specified under the above contract.

The results of this study will assist in determining the future water needs of the area. The data and interpretative information developed will be the basis for establishing present and future requirements for use, control, and conservation of water and related land resources of the Basin as they apply to flood control, navigation, hydroelectric power, municipal and industrial water supply, water-quality control, recreation, fish and wildlife, conservation, agriculture, and other water uses.

The study was undertaken in two phases. Phase I included (a) an inventory of available historical data regarding the Basin Service Area, (b) analysis of past growth and the present economy of the areas of interest, including a description of significant trends and a preliminary analysis of principal water-using industries, (c) delimitation of planning subareas, (d) analysis of national and regional economics to determine significant trends affecting the Basin Service Area, and (e) development of a method to project the demographic and economic characteristics of the Basin Service Area, the planning subareas, and the State of Michigan. Phase II completed the economic analysis of principal water-using and other key industries and developed the projections of population and economic activities for the Basin Service Area, the planning subareas, and the State of Michigan. This report summarizes the work done in both phases of the study.

This final report has incorporated a number of changes suggested during the review process, especially a number of clarification points suggested by the Informal Advisory Board. We wish to express our gratitude for the outstanding cooperation we enjoyed with members of your staff and the Informal Advisory Board throughout the course of this research program.

Sincerely yours,

E. E. Slowter
Associate Director

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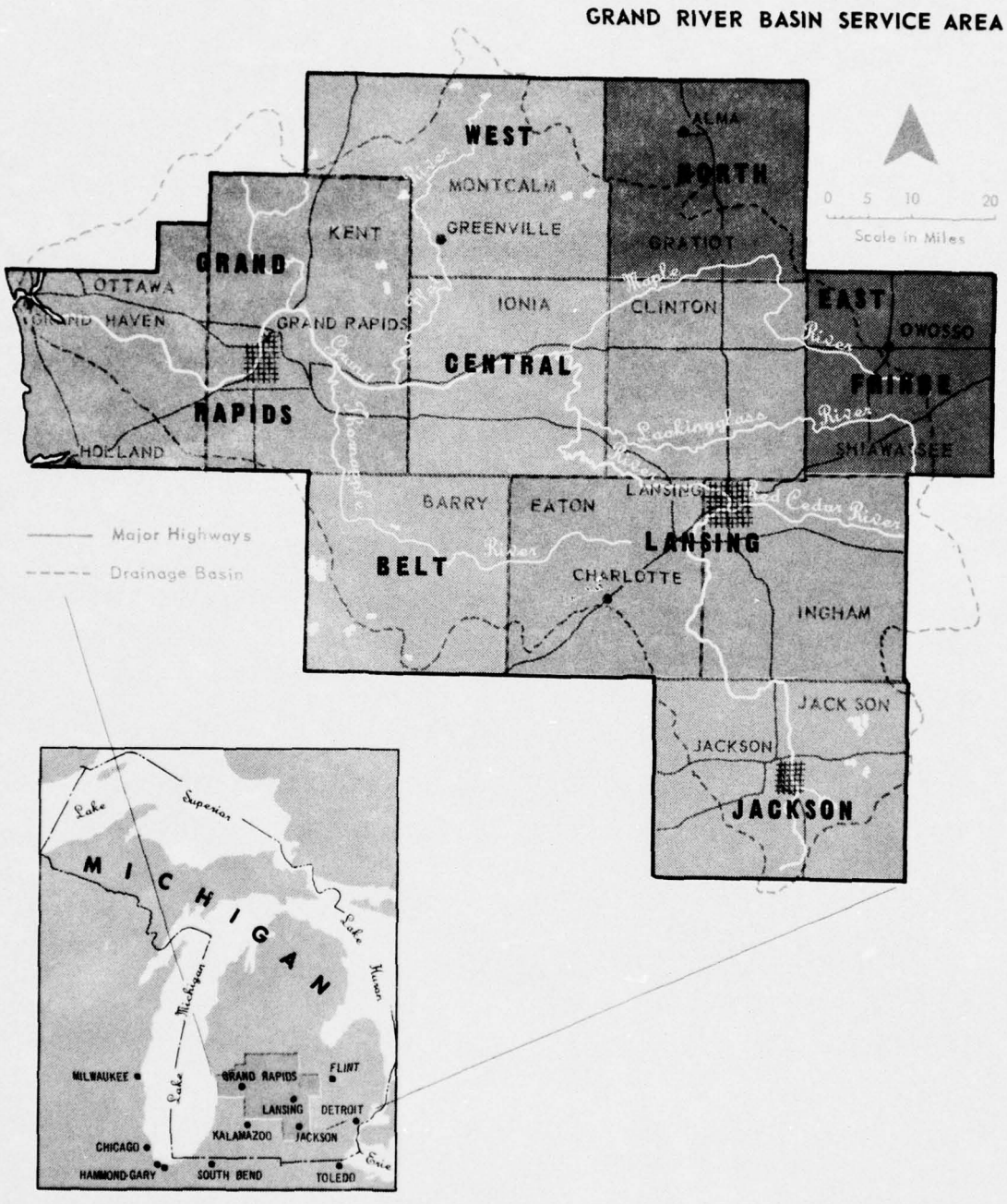


FRONTISPIECE

SUBAREAS IN THE GRAND RIVER BASIN

SUMMARY

Analysis of the social and economic forces which are expected to shape the economic future of the Grand River Basin Service Area (Barry, Clinton, Eaton, Gratiot, Ingham, Ionia, Jackson, Kent, Montcalm, Ottawa, and Shiawassee Counties in the State of Michigan, which are referred to in this report as the "Area") leads to the basic finding that the Area can be expected to grow and mature significantly during the six decades from 1960 to 2020. The economic and social development of the Area can be expressed in terms of three indices: population, employment, and industry structure. Each is summarized below.

The projections in this report are based on two major assumptions. The first is that limited availability of water will not constrain the expansion of industries currently in the Basin, provided that wise use is made of the Basin's water resources. The second is that Federal and State redevelopment programs are not expected to affect the development of this relatively prosperous area.

This report contains a number of tables reporting projected employment levels in the Basin and its subareas. It should be noted that in all cases projections of population, employment, and production are subject to uncertainties. In general, the estimates for the near term are more reliable than estimates for the long term; the estimates for major geographic aggregates are more reliable than estimates for smaller geographic areas; and estimates for aggregate industrial classifications are more reliable than for detailed and specific industry projections. Those variations in quality of projections which are related to the availability and reliability of historical data are noted in the sources cited.

Population

Growth in population in the Area from 1.1-million persons in 1960 to 1.5-million persons in 1980 and 2.9-million persons in

2020 is comparable with the growth expected for the Nation. However, the population growth will not be similar in all portions of the Area. Population growth in the Nation, Area, and subareas is given in Summary Table 1. The counties in the planning subareas are shown in the frontispiece.

SUMMARY TABLE 1. POPULATION PROJECTIONS

Geographic Unit	Thousands of Persons				Annual Rates of Change, per cent		
	1960	1970	1980	2020	1960-1970	1970-1980	1980-2020
United States	179,323	208,996	245,313	470,442	1.5	1.6	1.6
Michigan	7,823	8,954	10,413	19,103	1.4	1.5	1.5
The Area	1,094	1,272	1,506	2,881	1.5	1.7	1.6
Grand Rapids	462	535	636	1,243	1.5	1.7	1.7
West Central Belt	111	125	143	233	1.3	1.3	1.1
Lansing	299	359	435	868	1.8	1.9	1.7
Northeast Fringe	90	100	116	199	1.0	1.4	1.4
Jackson	132	152	177	339	1.4	1.5	1.6

For purposes of planning water usage, the growth of households represents an alternative index of growth. For the Area, the number of households is expected to grow from 313,600 in 1960 to 401,000 in 1980 and 777,900 in 2020. The urbanization of the Area is expected to continue. In 1960, 66 per cent of the population lived in urban areas. By 1980, 72 per cent will be found in urban locations, and by 2020, 79 per cent.

Employment

Civilian employment in the Area equaled 392,009 workers in 1960. Employment is projected to expand 79,859 workers between 1960 and 1970. By 1980, the total number of persons employed in the Area is expected to equal 549,514, an increase of 39 per cent over the 1960 employment level. Unemployment is expected to drop from 5.1 per cent in 1960 to 4.5 per cent in 1980.

At the end of the projection period, 2020, the rate of labor-force participation is expected to be 3.9 percentage points lower than the 55.5 per cent reported in 1960. At the same time, employment is projected to equal 998,336 workers, with only 4 per cent of the labor force in the unemployed classification. The employment level in 2020 will be 2.5 times that attained in 1960. Employment trends in the U. S., Michigan, and the Area are given in Summary Table 2.

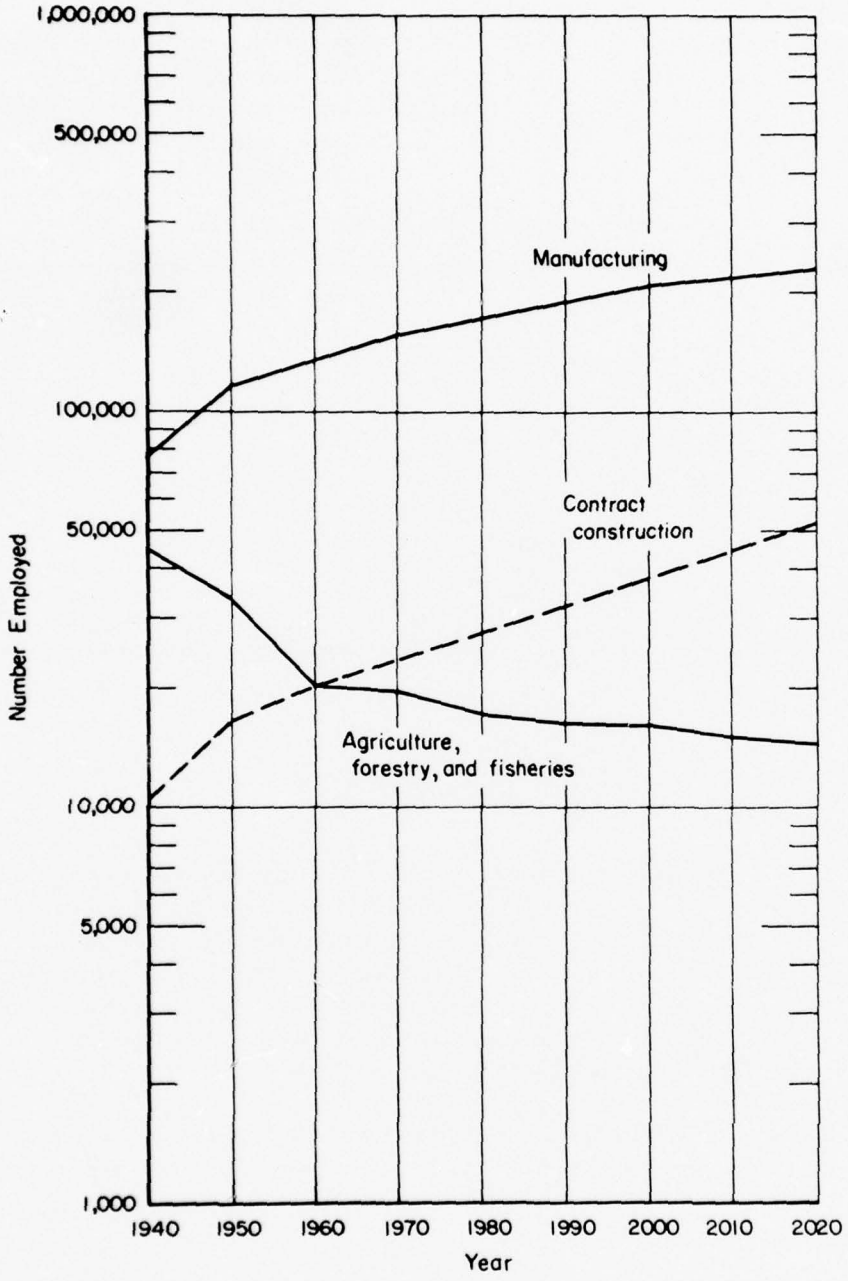
SUMMARY TABLE 2. EMPLOYMENT PROJECTIONS

Geographic Unit	Thousands of Persons				Annual Rates of Change, per cent		
	1960	1970	1980	2020	1960-1970	1970-1980	1980-2020
United States	64,639	78,701	91,104	171,000	2.0	1.5	1.6
Michigan	2,727	3,222	3,769	6,876	1.7	1.6	1.5
The Area	392	472	549	998	1.9	1.5	1.5
Grand Rapids	167	201	232	429	1.9	1.5	1.5
West Central Belt	38	44	50	77	1.6	1.3	1.1
Lansing	110	135	161	314	2.1	1.8	1.7
Northeast Fringe	31	38	43	67	1.8	1.5	1.1
Jackson	46	54	62	111	1.6	1.4	1.5

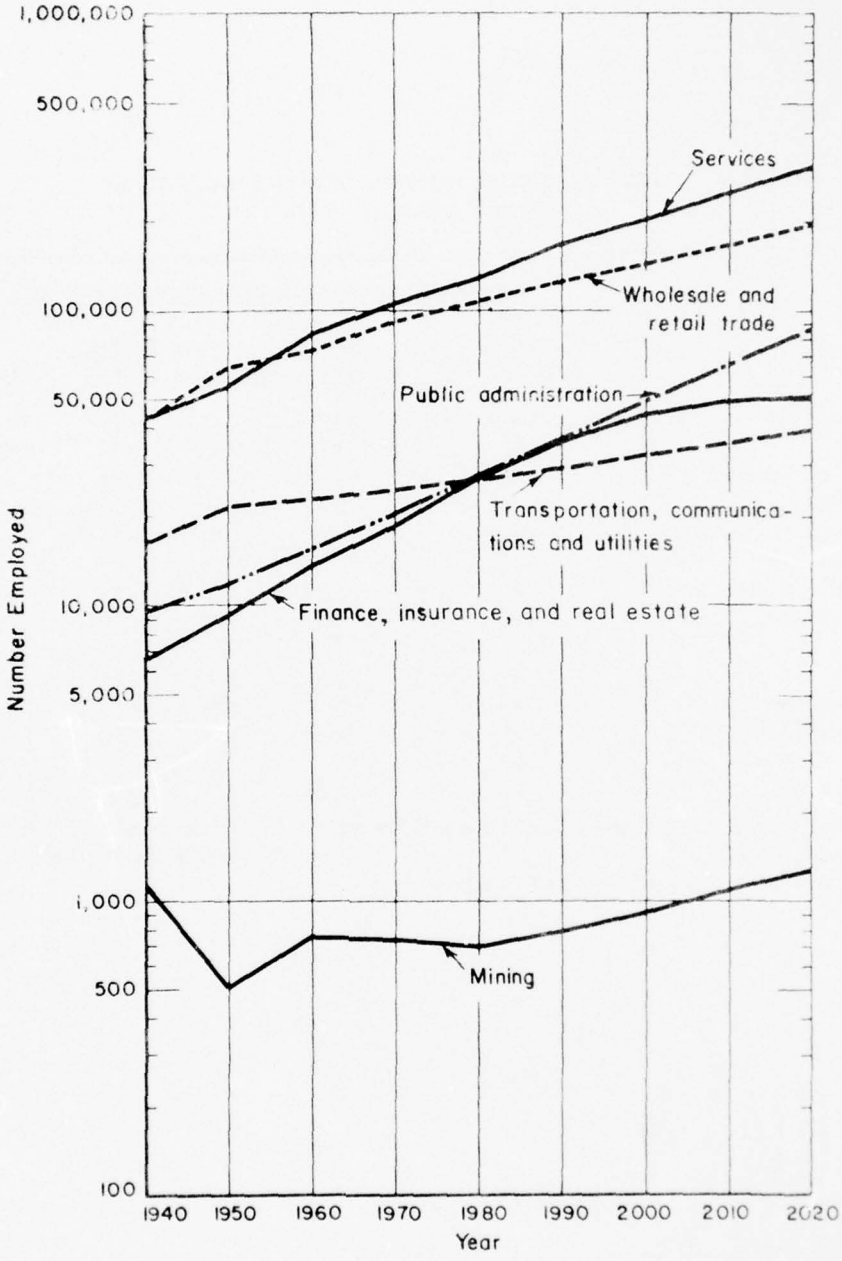
Employment Structure

The economic growth anticipated for the Area will be the result of many diverse trends. For example, as a result of relatively higher productivity, improvement in manufacturing, and anticipated shifts in consumer spending patterns, total employment growth in manufacturing will be less than that for over-all employment. The diverse employment-growth patterns by industry are shown in Summary Figures A and B.

Patterns of employment in each of the planning subareas also show divergent patterns. Summary Table 3 gives employment-growth rates from 1960 to 2020 by major industry division for each of the planning subareas.



SUMMARY FIGURE A. EMPLOYMENT BY INDUSTRY IN AREA, 1940-2020



SUMMARY FIGURE B. EMPLOYMENT BY INDUSTRY IN AREA, 1940-2020

SUMMARY TABLE 3. INDUSTRY DIVISION GROWTH RATES FOR THE PLANNING SUBAREAS - 1960-2020

Industry	Compound Annual Growth Rate, per cent, 1960-2020					
	Grand River Basin	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson
Agriculture, forestry, and fisheries	-0.6	-0.7	-0.5	-0.6	-0.4	-0.5
Mining	0.9	0.9	0.9	0.9	0.9	0.9
Contract construction	1.6	1.6	1.2	1.8	1.3	1.5
Manufacturing	0.9	1.0	0.9	0.6	1.0	0.7
Transportation, communications, and utilities	0.9	1.0	0.8	1.1	0.6	0.9
Wholesale and retail trade	1.6	1.7	1.5	1.7	1.3	1.6
Finance, insurance, and real estate	2.2	2.3	2.1	2.2	2.2	2.3
Services	2.2	2.1	1.7	2.4	1.8	2.2
Public administration	2.9	2.9	2.7	2.9	2.8	2.9
Industry not reported	1.9	2.3	1.5	1.7	2.5	1.6
All Industries	1.6	1.6	1.2	1.8	1.3	1.5

Source: The employment levels for major industry sectors in each of the planning subareas and the Area are reported in Table 81.

GRAND RIVER, MICHIGAN COMPREHENSIVE BASIN STUDY - ECONOMIC-BASE STUDY

INTRODUCTION

This economic-base study was prepared under contract between the U. S. Corps of Engineers and Battelle Memorial Institute. The contract was administered and supervised by representatives of the Corps of Engineers, U. S. Army Engineer District, Detroit.

The work accomplished consists of an economic-base study of the Grand River Basin Service Area.* The study (1) characterizes the existing economy of the Area, (2) analyzes the economic forces which influence its future economic changes, (3) projects its future economy, and (4) identifies those aspects of its future economy that provide parameters to determine water-resources needs.

The Area has an area of approximately 7,400 square miles within the state of Michigan. The following eleven counties constitute the Area: Barry, Clinton, Eaton, Gratiot, Ingham, Ionia, Jackson, Kent, Montcalm, Ottawa, and Shiawassee. Since future economic development of the Grand River Basin Service Area will not occur in geographic isolation, the survey considers areas beyond the Area which influence economic development in the Area.

Economic and demographic data pertaining to the economic base of the Area have been developed for current and past periods, and their trends are shown; interrelationships among the variables are indicated, as are the relationships of the economies of the Area and planning subareas to the economies of the Nation and the state of Michigan. The data are based on the year 1960 and are projected for each succeeding decade to 2020.

This study includes an analysis of the principal features of the economy of the Nation and the determination of trends and prospective changes in these features. Analyses of population and economic activities are made for the Region (the state of Michigan), which influences the prospects for the Area.

*Herein referred to as the "Area".

The report identifies key industries in the Area, including the principal water-using industries. The analyses of growth and locational trends for these industries in the Nation, State, and the Area are made to contribute to the Area comprehensive analysis.

For the purpose of developing and implementing a water-resource plan, estimates of trends and prospective economic changes are developed for planning subareas of the Basin.

A projection methodology is then developed to make the demographic and economic projections for the State, Basin Service Area, and planning subareas. The projections are developed under the following assumptions:

(1) Sufficient quantities of water of acceptable quality will be available to support the economy and facilitate economic growth.

(2) No major depressions will occur, and the Nation will have reasonably full employment (although not necessarily for the Area).

(3) Those assumptions implicit in special studies furnished to the Contractor by other agencies.

In estimating the potential growth in economic activity for the Area, it is necessary to assume that the water supply will be sufficient to accommodate such growth, as stated in Assumption 1. However, ample water is a resource which provides a region with a locational competitive advantage which may serve to attract industry from water-scarce areas. Since water facilities will be constructed throughout the Nation over the next 50 years, there is no way of anticipating which areas, if any, will be faced with serious problems of water shortages. Therefore, it is also necessary to assume that every area will have a future water supply ample to meet its economic growth prospects. In this way, consistency is maintained between the Area and national regional projections. The method of projections provides, however, for subsequent development of data to be used later in analyses of (1) the adverse economic effects of failure to develop water supplies of adequate quantity and quality in the Area or (2) the economic growth that would be associated with an adequate water supply. In addition, provisions are made in the methodology for evaluation of possible effects of Federal and State redevelopment programs in the Area.

Cooperative Organizations and Their Responsibilities

Various State and Federal agencies have provided special and contributing studies, critique, and information for the economic-base study. In addition, information has been provided by many of the local units of government, universities, city and regional planning commissions, and private organizations located both within and out of the Area. These cooperating agencies and organizations are partly identified in the "Bibliography".

Cooperation has been achieved with local units of government and other organizations through informal contacts and discussions both by Battelle Memorial Institute and Corps of Engineers' representatives.

Federal and State agencies have cooperated in two ways. First, by contributing studies prepared by their own staffs, and, second, by active participation through the medium of an Informal Advisory Board.

Contributing studies were prepared by the Federal Power Commission, which provided projections on power requirements and supply developed in conjunction with the National Power Survey; the Economic Research Service and Forest Service, U. S. Department of Agriculture, which provided projections on the agricultural economy and rural population and employment; and the Bureau of Mines, which provided historical mineral-production data and projected mineral-production data, partly based on estimates of future construction activities furnished by the Corps of Engineers.

A Grand River Basin Economic Base Study Informal Advisory Board was established, consisting of representatives of the Corps of Engineers; U. S. Public Health Service; U. S. Department of Commerce; U. S. Department of the Interior; Economic Research Service, U. S. Department of Agriculture; the Federal Power Commission; and the state of Michigan. The purpose of the Board was to confer with and to advise Battelle Memorial Institute and the Corps of Engineers. The Michigan Employment Security Commission provided assistance through a representative's participation at the Board meetings.

Relationship of the Economic-Base Study to the Comprehensive Study

The economic-base study projects the nature and extent of the future economic activity and growth in the Area. Since water needs are generated from population growth, economic growth, and changes in technology, these economic projections will be used to establish the Area's water needs as determined by both quality and quantity criteria.

From the water-needs data developed by the comprehensive basin-wide survey, quantitative and time-phased requirements for present and future control, use, and conservation of water and related land resources of the Basin will be determined by the Corps of Engineers cooperatively with other agencies for purposes of flood control, navigation, hydroelectric power, municipal and industrial water supply, water-quality control, recreation, fish and wildlife conservation, agriculture, and other water uses. To satisfy the water requirements, a comprehensive water-resources development plan for the Grand River basin will be prepared by the Corps of Engineers in cooperation with other Federal agencies and State and local governments.

I-A. UNITED STATES DEMOGRAPHIC AND ECONOMIC PROJECTIONS

I-1. Introduction

Purpose

While the major goal of this analysis is to yield detailed projections pertaining to the economic future of the Grand River Basin Service Area and the delimited Subareas therein, it is necessary to include in the analysis projections of certain demographic and economic factors for the Nation to provide the over-all framework for the analysis of the Area and Subareas.*

Analysis of past trends in such major factors as population indicates that there is not a precise relationship between trends in

*The specific national projections presented in this report are within the range of projections which appear in Economic Task Group of the Ad Hoc Water Resources Council Staff, National Economic Growth Projections 1980, 2000, 2020; Ad Hoc Water Resources Council, July 1963.

the Nation and trends in the Area. This is particularly true over relatively short periods of time, such as a decade. Nevertheless, it has been true, and will continue to be true, that general directions of movement in the Area will tend to follow, in a broad way, national trends. The nature of this historical relationship may be illustrated by population. Between 1900 and 1960, population in the Area increased by nearly the same percentage as in the United States. However, interim data indicate that the Area's population growth has not been closely tied to that of the Nation in most decades.

In light of the fact that projections for the Area are made for a 60-year period from 1960 to 2020, it is necessary to recognize that the general economic development of the Area will tend to follow that of the Nation and therefore to project growth of the Nation as well as that of the Area. Furthermore, much of the Area's future economic activity will be directly determined by the Nation's growth and the demand for transportation equipment.

Scope

Since the purpose of the national projection is to provide outlines of the general economic environment between 1960 and 2020, the national projections are limited in detail. For purposes of this analysis, projections have been undertaken for the following demographic and economic factors:

Population

Households

Labor force

Employment

Gross national product

Assumptions

In the light of the fact that the project period for this analysis is 60 years, relatively few general assumptions need be made. Additional specific assumptions, pertaining to individual demographic and economic projections, are stated in the

appropriate sections below. The general assumptions are limited to the following:

(1) During the projection period, 1960-2020, there will be no major economic recessions which will seriously affect the long-term growth patterns of the Nation's economy. The Nation will have relatively full employment.

(2) International political tensions will remain at approximately the present level. However, the military requirements for manpower are assumed to decline somewhat as we move into the future.

(3) Future price changes will not significantly affect the projected economic relationships. It is assumed that there will be inflation. However, the projections are in terms of constant prices to provide a better basis for evaluating future economic trends for planning purposes.

I-2. Methodology

A detailed statement of methodology is set forth in the following sections pertaining to the individual demographic and economic factors which have been projected. However, a general statement of methodology will serve to place the individual components in perspective and also detail the over-all approach used in the course of this research.

The general methodology should be divided into two major components: (1) that pertaining to the period from 1960 to 1980 and (2) that pertaining to the period from 1980 to 2020. A separate, more detailed methodology, developed in studies by Battelle's Socio-Economic Research Group over the past 4 years, has been employed for the earlier time period in order to incorporate the greatest degree of precision possible for shorter-term projections and thereby improve the bases for immediate planning.

Battelle's studies, primarily financed with Battelle funds but with some outside sponsorship, were designed to uncover the major forces that shape the present and future structure of the economy. As a result of these studies, the Socio-Economics Research Group has developed an analytical framework – the Battelle socio-economic model – which has been applied to intermediate-term projections for the economy of the Nation as a whole as well as to various aspects of regional economies. This model was not designed to project either nationally or regionally (a county, group of counties, a state, or a group of states) for periods of time significantly in excess of 20 years from the base year.

Therefore, only demographic and economic projections for the Nation, State, and Area through 1980 have been undertaken within the framework of Battelle's socioeconomic model. A separate, but not unrelated, methodology produces projections for the Grand River Basin Service Area for the period 1990 through 2020. Application of both methodologies follows a series of successive steps (some of which are carried out simultaneously). The following generally describes each of these steps.

Step I. Population Projections (Including Households). The first necessary input to the projection of the national economy (or to any regional economy) is a projection of population. The national projection used in this case is the official "Series B" projection of the U. S. Department of Commerce, Bureau of the Census.* Census projections of population are directly adapted for the projection period from 1960 through 2010. Estimates for 2020 are derived by extrapolating the Census projections for the period from 2000 to 2010 to the terminal year, 2020.

Projections of number of households are derived through an analysis of the dependency ratio of the population; that is, an examination of the projected age distribution of the population and the determination of the proportion of future inhabitants in the 0-19 age group to the number in the 20 years and over age group. These future dependency ratios are applied to the 1960 data on average size of household to obtain projected household sizes. These projected sizes (number of persons per household) are then applied to the projected population (in households) to determine projected numbers of households.

*U. S. Department of Commerce, Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 286 (July 1964).

Step II. Labor Force. An examination of historic patterns in labor-force participation, that is the proportion of the population 14 years and over in the labor force (both employed and unemployed), was undertaken to project labor-force participation rates through 1980. The projection of aggregate labor-force participation is developed by an analysis of labor-force participation by 5-year age cohort, considering variations in educational attainment. As a result of the tendency for participation to increase with higher levels of education, the 1980 rate is projected to equal 56. 1 per cent compared with 55. 3 per cent for 1960. For the period 1990-2020 the aggregate participation rate is projected to decline as a result of early retirement, longer periods of formal education, training and retraining, and withdrawal of selected marginal labor-force groups. By 2020 the labor force participation rate will decline to 53. 4 per cent of the population 14 years and older.

Step III. Employment. Battelle's research has led to certain conclusions regarding the important underlying social and economic forces shaping the future of the Nation's economy.

(1) On the national level, employment has begun to shift significantly from manufacturing industries to those industries that might be classified as nonproduct or service industries.

(2) The occupational structure (i. e. , numbers of people in various broad occupational classes, such as professional and technical, clerical, service, craftsmen, operatives, etc.) of the Nation has been undergoing dramatic shifts in recent years as a result of significant technological change. This changing structure reflects an increasing emphasis on those occupations requiring "brainpower" input in contrast to physical labor. This structural change is referred to as "the human resources era".

(3) Consistent with the shift toward human-resources-oriented occupations, there is an increasing demand for a labor force with high levels of skill and training that are, in turn, primarily derived from high levels of formal educational attainment.

(4) At the same time, there has been a relative decrease in job opportunities for those individuals having low skill levels and low levels of educational attainment.

(5) The shift toward human-resources-oriented occupations carried with it a shift toward higher average incomes and consequent changes in the structure of demand for goods and services.

Battelle's research has led to the conclusion that these basic shifts in the economy will continue at least until 1980 and will therefore have a significant impact on the nation's economy (as well as the economy of Michigan, the Area, and subareas). As a result, the application of the Battelle socioeconomic model, which quantifies the impact of each of these underlying trends, yields a detailed, estimated profile of the Nation's economy as well as that of Michigan, the Area, and subareas for both 1970 and 1980.

Figure 1 shows schematically how the various substeps in the Battelle projection methodology are interrelated. Each of the matrices in Figure 1 is labeled with a letter designation; references in the following description of the methodology are to these individual matrices.

The first substep is to project the percentage distribution of demand for labor in terms of occupation by industry for each of the terminal years (Matrix K). In this step the following industries are considered:

Agriculture
Mining
Contract construction
Durable-goods manufacture
Nondurable-goods manufacture
Transportation
Telephone, telegraph, and communication
Utilities
Wholesale trade
Retail trade
Finance, insurance, and real estate
Business repair services
Personal services
Entertainment and recreation
Professional services
Public administration

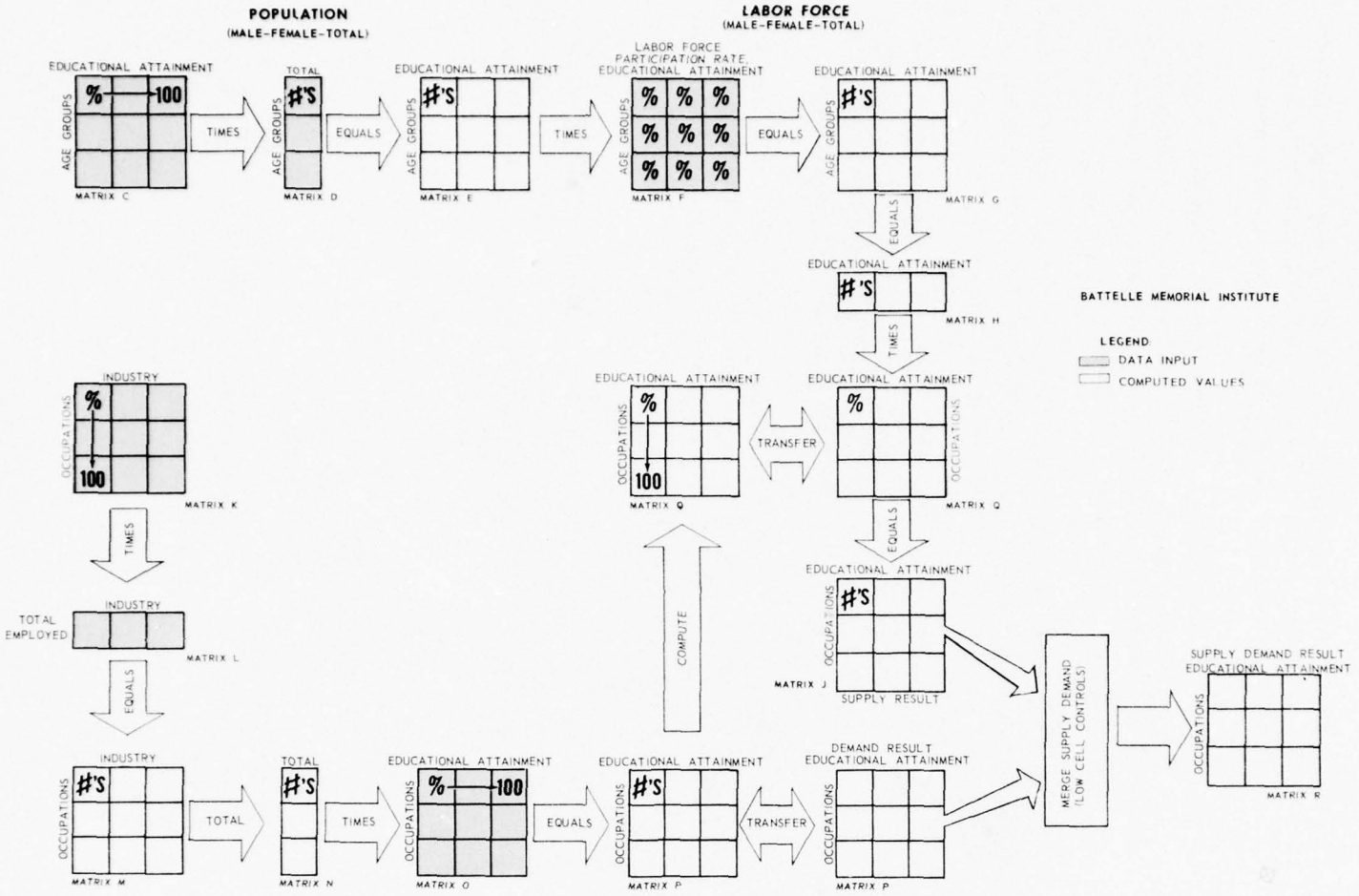


FIGURE 1. SOCIO-ECONOMIC MODEL

For each of these industries a projection is made of the percentage of total employment likely to be accounted for by people in each of the following major occupational categories:

Professional and technical
Managers, officials, and proprietors
Clerical
Sales
Craftsmen
Operatives
Private household workers
Service
Laborers
Farm laborers
Farm managers

This projection is made through an analysis of the trend in this distribution nationally, particularly between 1950 and 1960. In subsequent projections, similar analysis is undertaken for Michigan and the Area.

The second substep in the projection of demand for labor is to project anticipated total employment (without regard to occupation) for each of the industry groups listed above. This projection of total employment is undertaken through analysis of employment patterns in each of these major industry groups in the nation and subsequently in the state, Area, and subareas, taking into account the shifts from manufacturing to nonproduct-oriented industries (Matrix L).

The third substep in the projection methodology is to apply the projected occupation-by-industry distribution (Matrix K) to the projected total employment by industry (Matrix L) to determine the projected number of people demanded in each occupation in each of the industries considered (Matrix M).

This projected matrix of numbers of people by occupation and industry is then collapsed in the next step in the projection methodology. A projection of the total number of people demanded in each of the 11 major occupational categories is given in Matrix N.

To match the projected demand for employment of numbers of people by occupation against the available supply of people with requisite skills, it is necessary to convert the projected occupational demand (Matrix N) to numbers of people by levels of

educational attainment. Therefore, a projection is made of the percentage distribution of numbers of people in each occupation having various levels of educational attainment. These levels of educational attainment are

0 to 7 years
8 years – a grade-school education
9 to 11 years
12 years – a high-school education
1 to 3 years of college
4 or more years of college.

Analysis of the educational attainment of people in each of the 11 major occupational groups is used to project the percentage distribution of the people by level of educational attainment for each of the terminal years. As mentioned above, the levels of educational attainment that are characteristic of people in various occupations differ markedly. Furthermore, there has been a general upgrading of the educational attainment of early age groups; and as these groups move through the population and labor force, there is a gradual upgrading of over-all educational attainment. In addition, the increased sophistication of many occupations, combined with the decreasing significance of low-skill occupations, results in changes in the educational attainment required by the various major occupational groupings. These important trends are projected to arrive at a future percentage distribution of educational attainment of people in various occupations (Matrix O).

The next step in the projection of the demand for people is to convert the demand for numbers of people in various occupations (Matrix N) to numbers of people in each occupation with various levels of educational attainment (Matrix P) by multiplying the projected demand for people by occupation by the projected distribution of educational attainment by occupation. This projected matrix (Matrix P) is then converted into a percentage distribution in order to yield the projected percentage distribution of occupations for people having various levels of educational attainment. In other words, a projection is made of the percentage of people having 0 to 7 years of education in the professional and technical occupations, clerical occupations, service occupations, etc., for each of the major occupational groups. This distribution is shown in Figure 1 as Matrix Q. Matrix Q is derived directly from Matrix P, the projected demand for numbers of people in each occupation by various levels of educational attainment. This matrix (Matrix P) constitutes the projected demand for labor.

The subsequent series of substeps in the methodology is to project the supply of available people with requisite skills and then finally to match this available supply with projected demand to determine actual projected employment.

First in the series of supply projection substeps is a projection of the percentage distribution of the population by age groups that will have various levels of educational attainment in each of the terminal years, 1970 and 1980 (Matrix C). The age groups considered in this projection are as follows:

14-19	45-49
20-24	50-54
25-29	55-59
30-34	60-64
35-39	65-74
40-44	75+

Enrollment levels for persons less than 14 years old are also projected to indicate the base for future education. Of course, dropout rates for these younger age groups do not vary widely from area to area as they do for the older groups.

The educational-attainment matrix is projected by analyzing past trends in levels of educational attainment by various age groups of the population. This is essentially a system of estimating those people who are still in the educational stream through a projection of likely dropout rates at various levels of educational attainment.

Once the percentage distribution of educational attainment by age groups is projected (Matrix C), it is applied to the projection of population (by individual age groups – Matrix D) to yield a projection of the number of people in the population who will have various levels of educational attainment. This projection (Matrix E), then, constitutes the educational profile of the population by age group. This population serves as the potential labor force of the Nation.

Battelle's research has determined that there are significant differences both in level and in trend in labor-force participation rates for people in various age groups and for those having various levels of educational attainment. Therefore, the next substep in the projection method involves a projection of labor-force

participation rate (Matrix F) for those people having various levels of educational attainment in each of the various age groups. This projection is based on analysis of historical trends in labor-force participation rates.

After the participation rates for those having various levels of educational attainment in each of the various age groups are projected, these labor-force participation rates are applied to the projected population (in terms of age groups and levels of educational attainment) to determine the labor force (supply of labor) in terms of numbers of people having various levels of educational attainment within each of the specified age groups (Matrix G). This projected matrix is collapsed to yield total numbers of people in the labor force (without regard to age) at each of the various levels of educational attainment (Matrix H). This is the supply of labor in terms of people having various levels of educational attainment.

The next problem in the projection methodology is to determine how this supply might be distributed in light of the existing demand for people having various levels of educational attainment. On the theory that, over time, people with high levels of educational attainment will be attracted to those jobs requiring (and rewarding) such levels of educational attainment, the supply (labor force) is distributed in proportion to the projected demand for people at various levels of educational attainment among the major occupational groups (Matrix Q).

Once the available supply is so distributed and thereby becomes a supply of labor for each of the major occupations in terms of educational attainment (Matrix J), it is possible to match that projected supply against the projected demand for labor in terms of educational attainment.

In the national projection, the supply (a given level of educational attainment) and demand (a given occupation) are matched by allowing the lower of supply or demand to be displayed in each cell.

The detailed analysis outlined above yielded projections of educational attainment and projections of employment by industry for the years 1970 and 1980. A different method was used to make the post-1980 projections. Labor-force participation rates, as projected above, are applied against the projected national population for this time period. An assumption is made in regard to unemployment rates and thereby total national employment is derived. It has been assumed that unemployment will decline to 4 per cent by 2010.

Gross National Product. Gross national product is projected by first projecting national income*. Gross national product is ultimately derived by expanding national income to gross national product on the basis of a historic relationship between these two measures of aggregate economic activity.

National income may be conceptually viewed as the total of value added in each of the Nation's components of industrial activity. Therefore, it can be derived from the summation of value added (precisely defined as national income originating in each sector of economic activity per worker). These projections for the entire forecast time period, 1960-2020, are made through an analysis of historic trends in value added per worker in the major industrial classifications.

I-3. Population and Economic Activity: Historical Trends and Projections

Population

As indicated above, the national population projection used in this analysis is that prepared by the U.S. Bureau of Census in 1964. The Census series "B", which is the second highest projection**, has been selected. The apparent fertility rates experienced since 1960 have led to the selection of this series as the most appropriate.

The Bureau of Census has made projections only through the year 2010. Therefore, it has been necessary to independently generate a projected national population for the year 2020. The estimate for that year was derived by extrapolating the change from 2000 to 2010 to 2020.

Table 1 sets forth historical data showing population of the United States since 1900 and the projected levels through 2020.

* Gross national product is defined as the final value of all goods and services produced in the economy in any given time period (a year). National income is equivalent to gross national product less capital consumption allowances (depreciation and amortization, principally), indirect business taxes and business transfer payments, plus Government subsidies minus surplus of Government enterprises.

** The four projections currently available from Census differ primarily because of differences in assumed future fertility rates. According to Current Population Reports, "Population Estimates" (July 1964):

> "The assumed levels of completed fertility under Series B are scaled down somewhat from those used under Series A. The series is considered a moderately high series in that it presumes only a modest drop from the levels of fertility in the last decade. The Series B rates were developed by first establishing, as before, the completed level for the 30-to-34-year-old group. It was assumed that, by 1962, the group had completed about 82 per cent of its fertility (compared with 80 per cent for Series A), yielding a projected completed fertility of 3,234 children per 1,000 women. The completed fertility for the other cohorts was scaled so that the general pattern of change from cohort to cohort paralleled that of Series A."

TABLE 1. UNITED STATES POPULATION, 1900-2020

Year	Day	Population, millions
1900	June 1	76.2
1910	April 15	92.3
1920	January 1	106.0
1930	April 1	123.2
1940	April 1	132.2
1950	April 1	151.3
1960	April 1	179.3
1970	--	209.0
1980	--	245.3
1990	--	288.2
2000	--	338.2
2010	--	399.3
2020	--	470.4

Sources:

1900-1960: 1960 Census of Population, Vol 1, Characteristics of the Population, Part 1, U. S. Summary.

1970-2010: U. S. Department of Commerce, *Bureau of the Census*, Current Population Reports, "Population Estimates", Series P-25, No. 286, p 30 (July 1964). Series B projections.

2020: Battelle estimate.

Households

The Bureau of Census defines a household as consisting of all persons who occupy a housing unit. A house, an apartment, or other group of rooms, or other single rooms, are regarded as a housing unit when it is occupied or intended for occupancy as separate living quarters. Households generally cover all the population except those living in institutions, lodging in boarding houses, military and other types of barracks, college dormitories, fraternity and sorority houses, hospitals, homes for nurses, convents, monasteries, and ships.*

*U. S. Department of Commerce, Bureau of the Census, Census of Population: 1960, United States Summary, p LV.

The projection of number of households in the Nation is derived from the Census projection of total population. The present average size of household as well as those in the future will depend on the relative proportions of the population 19 years and younger and 20 years and over. The ratio of these two proportions, called the "dependency ratio" and usually expressed as a percentage, is used to modify the present average household size in the process of converting future population into households.

Not all of the nation's population lives in households. In 1960, 97.2 per cent of the population lived in households. In 1950, 96.2 per cent were so classified. In the national projection, the proportion living in households is assumed constant from 1960 to 2020. Therefore, the first step in estimating the number of households and the population in households is to apply this factor (97.2 per cent) to the projected total population. The second step is to examine the percentage increase in the dependency ratio through successive decades and to apply the rate of growth in the dependency ratio to the 1960 average size of household. In 1960, the average household size (that is, the total number of people living in households divided by the total number of households) was 3.290 persons. In 1960, the dependency ratio was 62.6 per cent. By 1970, it is projected that this ratio will rise to 64.89 per cent and by 1980 to 64.92 per cent. To avoid conveying a false sense of precision, the dependency ratio from 1980 to 2020 is assumed constant.

Application of the rate of growth of the dependency ratio to the average household size of 3.29 persons per household in 1960 results in an estimate of average size of 3.41 persons in 1975 and slightly above 3.41 persons per household in 1980 and thereafter. When this average size is divided into the projected population (less 2.8 per cent for those not living in households) the estimates of numbers of households result. These data for the United States are set forth in Table 2. As may be noted from the data in the table, as a result of the projected increase in the average size of household, while total population increases from approximately 179 million in 1960 to over 470 million in 2020, an increase of over 160 per cent, the number of households increases only from approximately 53 million to 134 million, an increase of just in excess of 150 per cent.* Any projection of likely trends in the

*Some analysts believe that the average number of persons per household will continue to rise into the future. For instance, Bogue has projected, as a "medium estimate" an average figure of 3.41 persons in 1965 and 3.44 persons per household by 1975. [See Bogue, Population of the United States, The Free Press of Glencoe, Illinois (1959), p 775.]

number of persons per household is by definition highly conjectural. The application of the dependency ratio in the form outlined above lends some precision to the projection and, in our analysis, results in the projection of stability by 1980.

TABLE 2. UNITED STATES POPULATION AND NUMBER OF HOUSEHOLDS, 1950-2020

Year	Total	In Households	Average Size of Household, persons	Number of Households, thousands
1950	151,326	145,116	3.42	42,394
1960	179,326	174,373	3.29	53,021
1970	208,996	203,144	3.410	59,573
1980	245,313	238,444	3.412	69,884
1990	288,219	280,149	3.412	82,107
2000	338,219	328,749	3.412	96,351
2010	399,256	388,077	3.412	113,739
2020	470,442	457,270	3.412	134,018

Sources: 1950-1960: U. S. Department of Commerce, Bureau of the Census, Census of Population, 1960, Vol. I, Characteristics of the Population, Part 1, U. S. Summary.

1970-2020: U. S. Department of Commerce, Bureau of the Census, Current Population Reports, "Population Estimates", Series P-25, No. 286 (July 1964); Battelle estimates for 2020.

Projections of households, average size of household, and number of households by Battelle.

I-4. Labor Force

As indicated in the section on methodology, the projections of national labor force are made on a different basis for the years 1970 and 1980 and for the years thereafter.

The employment estimates for 1970 and 1980 are generated within the context of the socioeconomic model and require projections of educational attainment and of labor-force participation.

Educational Attainment

In the current analysis, the supply of skills in the labor force is defined in terms of formal education. One must recognize, of course, that actual skills in the labor force are the

result of formal education, formalized on-the-job training, and the informal upgrading of skill through experience. Immediate concern with formal education is justified by earlier Battelle studies, which have shown that the major constraint on the supply of skills will be a shortage of college-trained people. Recognizing that this shortage will exist, it is particularly appropriate to focus on formal education to determine what portion of the labor force could be further educated to the point of a college degree or its equivalent.

Formal education can be analyzed by examining the percentage distribution of selected age groups* through grade levels of educational achievement.** For example, analysis of the 1960 Census of the U. S. shows that 8 per cent of the 25 to 29-year-olds achieved an eighth-grade level of education, and dropped out at that point; 6.7 per cent left school after 9 years of schooling, 8.3 per cent after 10 years, 6.8 per cent after 11 years, and 37.6 per cent stopped their formal educational upon completion of high school. In comparison, 34.3 per cent of the 30-34 age group and 31.1 per cent of the 40-44 age group had stopped their formal education upon completion of high school.

Projection of the percentage distribution of years of school completed in 1970 and 1980 for each age group is derived from analysis of three trends. The first is the educational attainment of the age group when composed of different populations; for example, in 1950 and in 1960 the educational achievement of the 45 to 49 age group is derived by examining different sets of people.*** The second is the educational attainment of a given population in the past: the 45 to 49 age group in 1970 is the same group observed in the 35 to 39 age group in 1960. The third is the rate of change in educational attainment of the two groupings defined above.

The final educational-achievement profile of the population for 1970 and 1980 was derived by using the three trends mentioned

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* An age group, for instance people aged 25 to 29 years, refers to people of a given age range at a point in time.

** The term "grade level of educational achievement" refers to the number of years of completed formal education. For instance, 8 years, 12 years (a high-school education), or 4+ years of college.

*** People aged 25 to 29 in 1950 are in the age group 35 to 39 in 1960. By 1960, a different population or set of people falls in the 25 to 29 age group. A given population or set of people is the term applying to a fixed group of people as they pass through successive age groups.

above to extrapolate past rates of change and educational achievement and by judgmental adjustments to reflect anticipated acceleration in the growth of 2-year technical schools and increased pressures to complete college-degree work. These adjustments are dictated by the fact that, as a result of improvements in technology, the requirements for human resources will far exceed, in the first instance, the available human resources with requisite formal education. It is our belief that the wage incentives resulting from this imbalance will lead to some upward shift in the proportion of the population completing college and that society will make the adjustments necessary to provide the requisite instructors and physical facilities.

It is important to recognize that changes in such programs as on-the-job training may make it possible to utilize persons having achieved less than a college diploma in positions now requiring that level of formal education. Thus, it is possible that the equivalent of the projection shown here can be achieved outside of the system of formal education.

Labor-Force Participation

Once the educational attainment of the population, by age and by sex, is determined, the next step in moving to a determination of the labor force is to apply labor-force participation rates (defined as the proportion of the population either employed or unemployed) to the projected number of people in each age group having each of the various levels of education. These detailed projections are carried out only for the years 1980 and 1990.

The labor-force participation rate for people in their prime ages, roughly from 25 through 64, is very high, regardless of level of education. There is some increase in the participation rates as those in any age group achieve higher levels of education, but even those with very low levels of education have high participation rates. To project the labor-force participation rates for 1970 and 1980, it is necessary to focus primarily on younger age groups, for these are the people who presently have sufficiently low levels of participation to permit either increases or decreases. As a result of the fact that educational attainment will be increasing, more young people will stay in school, and hence the labor-force participation rates for these groups are projected to decrease. However, the downward adjustment cannot be made simply by removing the additional people who will be in school from the labor

force. Many of those staying in school will also be in the labor force as a result of holding part-time jobs.

The labor-force participation rates by level of educational attainment for 1960 were also used for 1970 and 1980. As a result of the projected increase in the educational attainment of the population, the over-all labor-force participation rate increases from a level of 54.0 per cent in 1960 to 55.4 per cent in 1970 and 55.1 per cent in 1980, even though the rates for each age group at each of the levels of education are constant in those 2 years. The participation rates used in the projection are those set forth in Table 3, which is based on a March, 1962, survey of the U.S. labor force.

The labor-force projections for the years 1990 through 2020 result from a less complex methodology than that used for 1970 and 1980. It is possible, from the Bureau of Census projections, to estimate the total population 14 years and over (that available for inclusion in the labor force) for each of the projection years. The basic method for determining labor force is to analyze the projected trend from 1960 to 1980 in labor force and labor-force participation rates in order to determine future participation rates and thereby to estimate the future size of the labor force. By 1980, there will be over 97 million in the labor force, and the population 14 and over will be nearly 174 million. By the year 2020, the population 14 and over will increase to more than 333 million. There will be strong incentives for a continuation of upgrading of educational attainment which will have occurred between 1960 and 1980. This will have a long-term effect (1980-2020) of tending to decrease labor-force participation rates once the abnormal labor-force growth of young adults (1960-1980) is absorbed. At the same time, there will be stronger incentives for progressively earlier retirement. This will tend to depress the labor-force participation rate for the entire population. Finally, the participation rate is also influenced by the quantity of job opportunities. The greater the opportunities for employment, the greater the likelihood that the participation rate will remain stable or even increase.

Considering the dampening effects of young people remaining in school for more years, early retirements, and job opportunities, a decline in the labor-force participation rate after 1980 is projected. In 1980 the rate is projected to be 55.1 per cent. By 2020 it is estimated that it will decline to 53.4 per cent. Application of the projected labor-force participation rates yields a labor force in 2020 of slightly over 178 million. The data for each of the years from 1960-2020 are set forth in Table 4.

TABLE 3. LABOR-FORCE PARTICIPATION RATES OF THE UNITED STATES POPULATION, BY AGE, SEX, AND YEARS OF SCHOOL COMPLETED, MARCH 1962

Years of School Completed and Sex		Per Cent of Population in Labor Force							
		Total, 18 Years and Over	18 and 19 Years	20 to 24 Years	25 to 34 Years	35 to 44 Years	45 to 54 Years	55 to 64 Years	65 Years and Over
				Both Sexes					
	Total	59.5	52.7	62.7	65.3	69.6	72.1	62.0	19.8
Elementary:	Less than 5 years[a]	40.3	(b)	57.4	61.2	67.6	65.2	53.3	13.6
	5 to 7 years	51.2	65.9	61.7	64.2	69.8	67.1	57.7	16.6
	8 years	53.3	65.3	62.0	65.3	68.7	70.3	59.5	19.1
High school:	1 to 3 years	61.6	44.9	59.7	63.7	69.9	71.3	64.2	25.3
	4 years	62.6	59.2	66.9	61.3	66.1	72.3	63.7	21.3
College:	1 to 3 years	61.5	40.8	53.2	67.6	68.2	75.3	63.4	31.3
	4 years	74.5	(b)	80.5	75.4	79.0	82.7	76.7	30.4
	5 years or more	86.0	--	61.9	87.4	93.3	91.7	89.9	43.0
				Male					
	Total	83.5	60.2	84.2	97.1	97.4	95.5	87.0	31.0
Elementary:	Less than 5 years	58.2	(b)	(b)	85.8	91.4	87.0	77.8	21.3
	5 to 7 years	74.6	84.3	90.5	94.1	94.5	92.4	83.4	26.2
	8 years	78.2	(b)	96.9	96.0	96.4	95.6	87.1	30.8
High school:	1 to 3 years	88.8	60.0	93.6	98.7	97.7	96.7	89.1	37.7
	4 years	90.7	61.3	94.3	98.6	98.1	97.0	90.6	36.0
College:	1 to 3 years	83.0	41.4	60.2	96.9	98.7	97.0	89.1	53.9
	4 years	92.4	(c)	82.0	97.5	98.8	98.1	93.2	45.0
	5 years or more	92.2	--	56.2	94.7	99.3	97.4	94.2	54.1
				Female					
	Total	38.1	46.2	45.0	36.7	44.1	49.9	38.8	10.7
Elementary:	Less than 5 years[a]	19.5	(b)	(b)	27.4	35.4	37.7	26.6	5.2
	5 to 7 years	20.8	(b)	31.0	29.6	40.7	40.4	32.1	8.9
	8 years	30.1	(b)	31.7	32.3	41.3	44.9	33.6	9.9
High school:	1 to 3 years	37.8	30.6	34.8	35.2	43.9	47.3	40.7	16.5
	4 years	43.2	57.8	48.9	36.3	44.4	53.4	43.7	12.1
College:	1 to 3 years	41.8	40.3	44.8	38.6	41.9	54.7	46.5	16.4
	4 years	53.9	(b)	79.3	46.8	52.2	68.0	58.7	16.6
	5 years or more	69.3	--	(b)	60.4	74.5	80.5	81.4	(b)

(a) Includes persons reporting no school years completed.

(b) Per cent not shown where base is less than 100,000.

Source: Johnston, Denis F., "Education Attainment of Workers, March 1962", Monthly Labor Review, p A-9 (May 1963).

TABLE 4. ADULT POPULATION, LABOR FORCE, AND EMPLOYMENT IN THE UNITED STATES, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Total Population 14 and Over[a], thousands	126,277	149,691	173,908	203,069	240,607	283,048	333,496
Labor-Force Participation Rate[b], per cent	54.0	55.4	55.1	54.8	53.8	53.7	53.4
Civilian Labor Force[b], thousands	68,144	82,930	95,800	111,200	129,400	152,000	178,000
Employed[b]	64,639	78,701	91,100	106,000	124,000	146,000	171,000
Unemployed[b]	3,505	4,229	4,700	5,200	5,400	6,000	7,000
Unemployment Rate[b], per cent	5.1	5.1	4.9	4.7	4.2	4.0	4.0

Note: Population 14 years and over for the years 1990-2010 was estimated by adding one-fifth of the population "10-14" to the population 15 and over as shown in the source. For 2020, population 14 and over was assumed to represent the same proportion of total population as in 2010.

Sources: (a) 1970-2010: U. S. Department of Commerce, Bureau of the Census, Current Population Estimates, Series P-25, No. 286 (July 1964): Series B projections Battelle estimates.

1990-2010: U. S. Bureau of the Census, Current Population Estimates, Series P-25, No. 286 (July 1964); Battelle estimates.

2020: Battelle estimates.

(b) 1960 estimates from: 1960: U. S. Department of Commerce, Bureau of the Census, U. S. Census of Population: 1960, Volume I, Characteristics of the Population, Part 1, U. S. Summary.

1970-2020: Battelle estimates.

Employment

Employment projections are also made on a separate basis for 1970 and 1980 and for the period after 1980. Projections from 1960 through 1980 are made on the basis of the socioeconomic model.

Recent data indicate a relative decline in employment opportunities in manufacturing and a continuation of the decline in jobs in agriculture. Offsetting these relative declines will be an increase in the number of jobs in service activities. Through a detailed analysis of individual major industry groups, a projection is made for 1970 and 1980 of the total number of job opportunities. These projections represent the demand for employees. When each of the individual industry projections are summed and ultimately matched against the available supply of people, we find a projected increase in employment to 78. 7 million in 1970 (from a level of 64. 6 million in 1960) and to 91. 1 million in 1980.

The initial projected levels of employment by industry are not directly comparable however with the projected available supply of people. A detailed analysis of occupation by major industry groups is undertaken and, consistent with the steady flow of improved technology and demands for better trained people, projections are made of the proportion of employment in each major industry group which will be accounted for by people in each of the major occupational categories. This distribution is projected to 1970 and also to 1980 and then applied to the projected total employment by industry to derive a projected employment by occupation estimate for each of the years.

This projected pattern of demand by occupation and by industry is then translated into demand for people by various levels of education. Average level of education in each of the major occupational groups has been generally increasing over the past few decades. This trend is expected to continue but, in light of the available supply of well-trained people, to proceed upward at a somewhat slower rate. Application of the projected educational patterns by occupation to the projected demand for employees by occupation results in a projected demand for employment by levels of education. This projection can be compared with the projected supply of people in terms of levels of educational attainment, and thereby the projected level of employment is derived.

A comparison of the projected employment levels for the nation for 1970 and 1980 indicate fairly high levels of employment for each of these years. In 1970, unemployment is estimated to

be 5.1 per cent of the labor force and, by 1980, to decline to 4.9 per cent. This higher level in 1970 is a reflection of the anticipated growth of young people in the population who, in light of their training and experience, will find difficulty in obtaining employment.

The projected levels of employment for the years from 1990 to 2020 are estimated by evaluation of the trends from 1960 to 1980 and a basic judgment that the relatively high levels of unemployment to be experienced until 1980 will begin to decline as a result of Government actions, such as the retraining programs initiated in the 1960's, and the growth of programs to encourage early withdrawal of marginal workers from the labor force. By projection, the 1990 unemployment rate will fall to 4.7 per cent and the year 2010 unemployment rate to 4.0 per cent. At the same time, employment is projected to increase from 91.1 million in 1980 to 106 million in 1990 and finally to 171 million by 2020. The details of the employment projection are set forth on Table 5. The large growth from 1960 to 1970 will be unmatched in any other decade throughout the remainder of the projection period.

TABLE 5. UNITED STATES EMPLOYMENT, 1950-2020

Year	Thousands of Persons	Percent Growth Over Previous Decade
1950	59,304	
1960	64,639	9.0
1970	78,701	21.8
1980	91,104	15.8
1990	106,000	16.4
2000	124,000	17.0
2010	146,000	17.7
2020	171,000	17.1

Source: 1950-1960: U. S. Department of Commerce, Bureau of the Census, Census of Population, 1960, Vol. I, Characteristics of the Population, Part 1, U. S. Summary.

1970-2020: Battelle Memorial Institute projections.

I-5. Gross National Product

Gross national product (GNP) is not directly projected by the socioeconomic model. In fact, no monetary estimates are

generated directly by the model. However, gross national product can be estimated within the context of the model by first estimating national income and then deriving gross national product from an estimate of national income.

The national income estimates used for 1970 and 1980 are derived from a detailed examination of the industry of employment of those projected to be employed and the average value added (national income) per worker which may be expected in each of the major industry groups in 1970 and 1980. Multiplication of the national income per worker estimates by the number projected to be employed in each industry yields, when summed, an estimate of national income. In 1960, national income was $414.5 billion. By 1980, it is estimated that it will increase to $900.0 billion, in 1960 prices. Gross national product has historically borne a very close relationship to national income and is thereby estimated by assuming that, in 1970 and 1980, national income will represent 84.0 per cent of gross national product. Therefore, GNP is estimated to reach $760.0 billion in 1970 and $1,080.0 billion by 1980.

Estimates for gross national product and national income for the years subsequent to 1980 are derived through assuming the same rate of growth for both national income and gross national product after 1980. The rate used to project each of these series for the years 1990 through 2020 was 3.8 per cent per year. Application of this rate to the 1980 projections indicates a national income of slightly in excess of $4.0 trillion in 2020 and a gross national product of $4.8 trillion by that year. The results of the projection of national income and of gross national product are set forth in Table 6.

TABLE 6. NATIONAL INCOME AND GROSS NATIONAL PRODUCT, 1960-2020

	Billions of 1960 Dollars	
Year	National Income	Gross National Product
1960	414.5	502.6
1970	640.0	760.0
1980	900.0	1,080.0
1990	1,320.0	1,570.0
2000	1,920.0	2,280.0
2010	2,770.0	3,300.0
2020	4,030.0	4,800.0

Source: 1960: Council of Economic Advisors, Economic Indicators.

1970-2020: Battelle projections.

I-B. GRAND RIVER BASIN

SECTION A. GRAND RIVER BASIN: POPULATION AND URBAN INDUSTRIAL ECONOMIC ACTIVITY (1940-1960)

I-6. Introduction

The purpose of this major section is to set forth the details of the projections made for the Region (Michigan), the Grand River Basin Service Area, and also the five planning subareas. Projections are provided for such major indicators as population, labor force, and employment, and detailed projections are made for major industry groups (such as manufacturing) as well as for certain "key" industries identified as likely to exert substantial influence on the economic future of the Area and subareas. To identify the environment in which these projections must be viewed, salient aspects of the past and present economic development of the Area and subareas are included.

I-7. The Past and the Present

The Area was originally defined for purposes of this research as comprising the Michigan counties of Barry, Clinton, Eaton, Gratiot, Ingham, Ionia, Jackson, Kent, Livingston, Montcalm, Ottawa, and Shiawassee. Research early in this project indicated that Livingston County, with only a minor portion lying within the Grand River watershed, has had and will have very little influence on the economic growth of the Area, for it has strong ties with Detroit to the east. For these reasons Battelle, in agreement with the Corps of Engineers, agreed to eliminate Livingston County from the Area. The remaining 11 counties were subsequently grouped into subareas.

Delimitation of the subareas within the Area is based on a large number of factors, all of which may have a bearing on water needs and supplies - the major subjects of the comprehensive study. The most important of these include analysis of economic service centers, other patterns of economic activity, Standard Metropolitan Statistical Areas, agricultural areas, and water-resource considerations. Other bases for delimitation include such factors as population characteristics, physiography, soils characteristics, and broad features of land use. Factors or bases for delimitation of subareas have been confined to the present situation and historic trends.

Delimitations or boundaries of subareas – as for the Area itself – must coincide with county lines, because of the unavailability of economic statistics of geographic units smaller than counties.

I-8. Subarea Delimitation and Justification

The delimitation of the subareas was influenced by the location of the Area's major economic service centers. Such major centers are dealt with for statistical purposes as Standard Metropolitan Statistical Areas (SMSA's). There are three such subareas in the Area: (1) Grand Rapids SMSA, comprising Kent and Ottawa Counties, (2) Lansing SMSA, comprising Clinton, Eaton, and Ingham Counties, and (3) Jackson SMSA, comprising Jackson County.

Because of the economic unit characteristics of SMSA's, each SMSA is designated as a subarea.

These three subareas are named as follows for convenience in identification:

Grand Rapids Subarea		Kent County Ottawa County
Lansing Subarea		Clinton County Eaton County Ingham County
Jackson Subarea	–	Jackson County

The five remaining counties are all comparatively low-population units, with low population density and generally low population growth over the period 1930-60. Further consideration of these five leads to a rather logical geographic grouping of Barry, Ionia, and Montcalm Counties as a continuous belt of predominantly agricultural land, similar physiographically, which also serves as a "neutral zone" between the Lansing and Grand Rapids SMSA's. Barry also separates the Grand Rapids SMSA from the City of Battle Creek.

Employment patterns in 1960 for these three counties show excellent correlations among the counties, as indicated by data in Table 8. The percentage employment for the four major industry employment groups – manufacturing, services, trade, and agriculture – is remarkably similar, and percentage employment in agriculture is relatively high compared with that for other subareas.

Agricultural data for 1959 show these three counties as the lowest in the Area in terms of value of farm land and buildings per acre; two of the counties (Montcalm and Barry) also were low in proportion of harvested cropland as a percentage of total land in farms (see Table 7). They were similar in showing high percentage losses in agricultural employment, 1940 to 1960, between 57 per cent and 61 per cent. In percentage of cropland to total land area, the three counties are intermediate, varying from 46 per cent for Barry to 57 per cent for Montcalm.* For these reasons, Barry, Ionia, and Montcalm Counties are grouped together into one subarea, termed the "West Central Belt".

Two counties – Gratiot and Shiawassee – remain for consideration. Shiawassee serves as a "buffer" between Lansing and Flint, while Gratiot is less influenced by large urban areas, being about equidistant from Lansing and Saginaw. Employment patterns of the two counties do not show the strong similarities of the three counties just discussed (see Table 8). However, it should be pointed out that both the counties have only about 50 per cent or less of their land area within the Grand River Basin and that the most important urbanized areas in the counties lie in the Saginaw River watershed (Alma and St. Louis in Gratiot County, and Owosso and Corunna in Shiawassee County), not in the Grand River watershed.

Agriculturally, the two counties are similar and distinctive in that farms show relatively high value of land and buildings per acre and high proportions of all cropland harvested (see Table 7). They also show the same high percentage of cropland to total land area (70 per cent for both).

*"An Inventory of Michigan Soil and Water Conservation Needs", Michigan State Agriculture Exp. Station and Michigan Conservation Needs Committee (October, 1962). This inventory is based upon a 2 per cent sample.

For the above reasons, Gratiot and Shiawassee Counties are grouped as one subarea named "Northeast Fringe".

The Area and subareas divisions described are shown in Figure 2.

I-9. Salient Economic Characteristics of Subareas

Salient economic characteristics of the five recommended subareas of the Area are summarized below. Table 7 presents major data on land area, population, and a few features of agriculture for each of the counties in the area and (except for agriculture) for the subareas. Table 8 gives number and percentage distribution of employed persons in 1960, by major industry group, for all counties and for the five recommended subareas.

Grand Rapids Subarea

The economy of this subarea is dominated by the city of Grand Rapids in Kent County, with a 1960 census population of 177,000. This was about 50 per cent of the Kent County population and 38 per cent of the total subarea population. Other important urban centers in the subarea are Holland and Grand Haven on Lake Michigan in Ottawa County. Population growth, 1930-1960, at 57 per cent for the subarea was comparatively high.

Gaged by 1960 employment by major industry groups, manufacturing dominated the field by employing 37 per cent of the total in the subarea, followed by trade and services with 20 per cent each. Agricultural employment was low at only 3 per cent of the total. Within manufacturing, the most important fields are fabricated metals, furniture and fixtures, and electrical machinery, in that order.

In agriculture, average size of farms in the subarea was the smallest in the Area, but average value of farm land and buildings per acre was high.

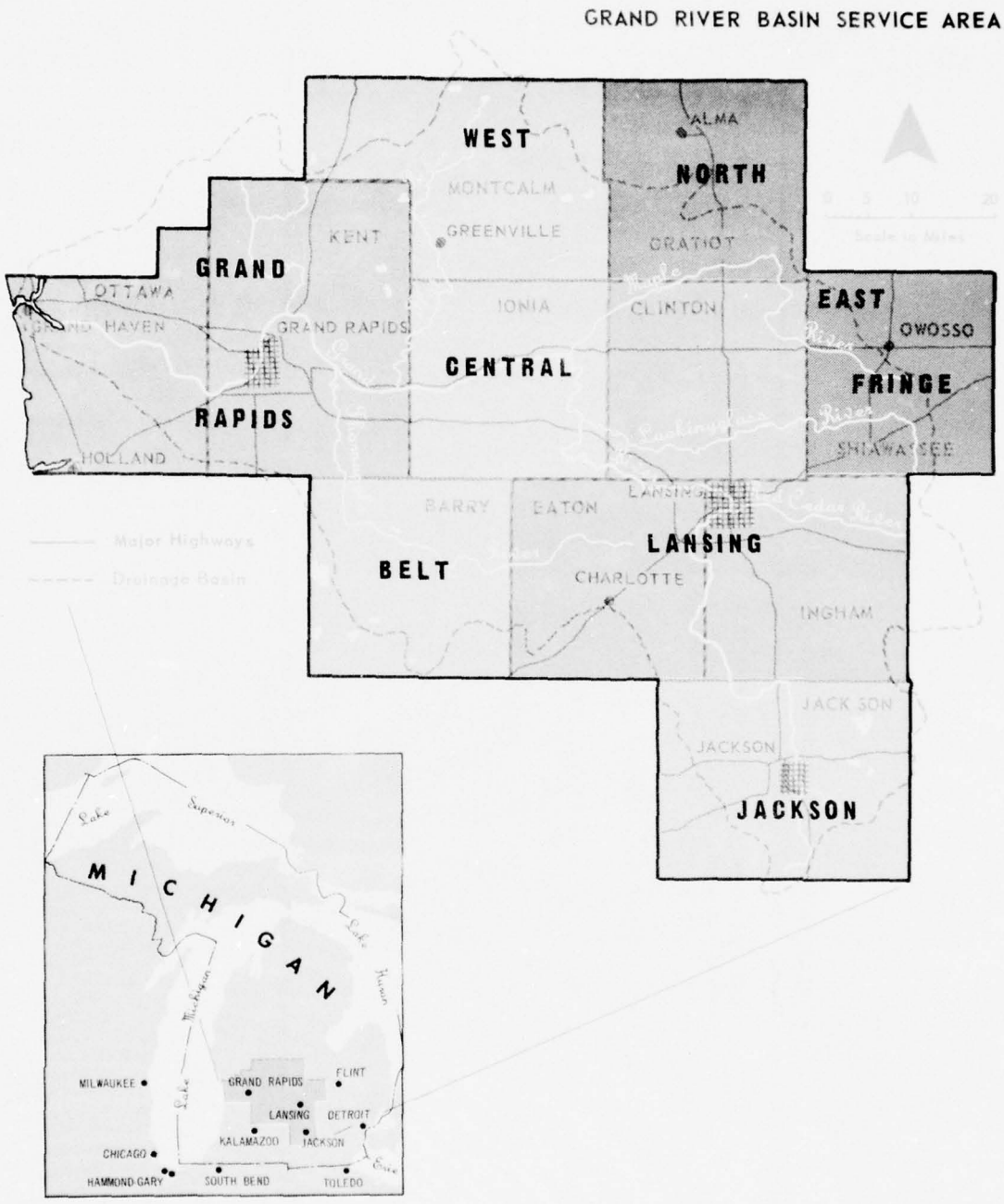

FIGURE 2. DELIMITATION OF SUBAREAS IN THE GRAND RIVER BASIN SERVICE AREA

TABLE 7. SALIENT DATA CONCERNING SUBAREAS OF THE GRAND RIVER BASIN SERVICE AREA

	Grand Rapids Subarea			West Central Belt Subarea				Lansing Subarea				Northeast Fringe Subarea			Jackson Subarea
	Kent	Ottawa	Total	Montcalm	Ionia	Barry	Total	Clinton	Eaton	Ingham	Total	Gratiot	Shiawassee	Total	Jackson
Land Area, sq mi	862	564	1,426	712	575	549	1,836	571	567	559	1,697	566	540	1,106	705
1960 Population	363,187	98,719	461,906	35,795	43,132	31,738	110,665	37,969	49,684	211,296	298,949	37,012	53,446	90,458	131,994
Population Per Sq Mile, 1960	421	175	324	50	75	58	60	66	88	378	176	65	99	82	187
Percentage Population Growth, 1930-1960	51	80	57	30	23	52	32	57	57	81	73	22	35	30	43
Average Size of Farms, 1959, acres	107.7	82.5	(a)	135.6	146.9	135.7	(a)	142.0	129.7	148.5	(a)	133.6	133.2	(a)	150.4
Average Value of Farm Land and Buildings Per Acre, 1959, dollars	210	238	(a)	140	162	123	(a)	192	206	240	(a)	241	232	(a)	183
Harvested Cropland as Percentage of Total Land in Farms, 1959	47.0	53.1	(a)	45.1	52.7	47.0	(a)	58.0	54.8	51.6	(a)	64.9	60.8	(a)	47.3

(a) Data not supplied for subarea by USDA.

TABLE 8. NUMBER AND PERCENTAGE DISTRIBUTION OF EMPLOYED PERSONS IN 1960, BY COUNTY AND MAJOR INDUSTRY GROUP, IN SUBAREAS OF THE GRAND RIVER BASIN SERVICE AREA

	Grand Rapids Subarea						West Central Belt Subarea							
	Kent	%	Ottawa	%	Total	%	Montcalm	%	Ionia	%	Barry	%	Total	%
Agriculture	2,732	2.1	2,390	6.9	5,122	3.1	1,661	13.2	1,666	12.2	1,389	12.2	4,716	12.5
Forestry and fisheries	43	--	34	0.1	77	--	--	--	--	--	--	--	0	--
Mining	267	0.2	80	0.2	347	0.2	29	0.2	4	--	27	0.2	60	0.2
Construction	6,757	5.1	2,056	5.9	8,813	5.3	579	4.6	535	3.9	623	5.5	1,737	4.6
Manufacturing	47,896	36.2	14,697	42.5	62,593	37.4	4,794	38.1	5,325	38.9	4,531	39.9	14,650	39.0
Transportation	5,148	3.9	993	2.9	6,141	3.7	257	2.0	172	1.2	241	2.1	670	1.8
Utilities, communications, sanitary services	3,149	2.4	663	1.9	3,812	2.3	224	1.8	263	1.9	191	1.7	678	1.8
Wholesale and retail trade	26,968	20.4	5,759	16.7	32,727	19.7	2,108	16.7	2,107	15.4	1,575	13.9	5,790	15.2
Finance, insurance, and real estate	5,494	4.2	830	2.4	6,324	3.8	237	1.9	271	2.0	258	2.3	766	2.0
Services	27,118	20.5	5,702	16.5	32,820	19.7	2,053	16.3	2,323	17.0	1,892	16.6	6,268	16.7
Public administration	3,433	2.6	725	2.1	4,158	2.5	265	2.1	611	4.5	247	2.2	1,123	3.0
Industry not reported	3,234	2.4	654	1.9	3,888	2.3	391	3.1	418	3.0	393	3.4	1,202	3.2
Total	132,239	100.0	34,583	100.0	166,822	100.0	12,598	100.0	13,695	100.0	11,367	100.0	37,660	100.0

	Lansing Subarea								Northeast Fringe Subarea						Jackson Subarea	
	Clinton	%	Eaton	%	Ingham	%	Total	%	Gratiot	%	Shiawassee	%	Total	%	Jackson	%
Agriculture	1,868	14.4	1,759	9.7	1,990	2.5	5,617	5.1	1,647	13.1	1,414	7.5	3,061	9.7	1,696	3.7
Forestry and fisheries	5	--	--	--	31	--	36	--	--	--	--	--		--	4	--
Mining	--	--	52	0.3	74	0.1	126	0.1	46	0.4	29	0.2	75	0.2	142	0.3
Construction	823	6.3	1,104	6.1	4,682	5.9	6,609	6.0	540	4.3	803	4.2	1,343	4.3	1,924	4.2
Manufacturing	4,088	31.4	6,064	33.6	19,392	24.5	29,544	26.8	3,943	31.4	7,684	40.7	11,627	37.1	16,256	35.5
Transportation	238	1.8	535	3.0	1,535	1.9	2,308	2.1	344	2.7	1,024	5.4	1,368	4.3	1,718	3.8
Utilities, communications, sanitary services	229	1.8	342	1.9	2,055	2.6	2,626	2.4	379	3.0	484	2.6	863	2.7	2,558	5.6
Wholesale and retail trade	2,182	16.8	3,033	16.8	14,401	18.2	19,616	17.8	2,310	18.4	2,900	15.3	5,210	16.6	8,324	18.2
Finance, insurance, and real estate	343	2.6	549	3.0	3,447	4.4	4,339	3.9	276	2.2	431	2.3	707	2.2	1,282	2.8
Services	2,197	16.9	3,474	19.3	22,732	28.7	28,403	25.8	2,582	20.6	3,223	17.1	5,805	18.5	8,510	18.6
Public administration	476	3.7	755	4.2	6,007	7.6	7,238	6.5	297	2.4	558	2.9	855	2.7	1,846	4.0
Industry not reported	560	4.3	380	2.1	2,876	3.6	3,816	3.5	188	1.5	349	1.8	537	1.7	1,539	3.3
Total	13,009	100.0	18,047	100.0	79,222	100.0	110,278	100.0	12,552	100.0	18,889	100.0	31,451	100.0	45,798	100.0

Source: 1960 Census of Population, Volume I, Characteristics of the Population, Part 24, Michigan, Table 85, p 817.

West Central Belt Subarea

This subarea comprises the predominantly rural counties of Montcalm, Ionia, and Barry, with comparatively low population and the lowest population density of all the five subareas. Also, percentage growth of population, 1930-1960, was low at only 32 per cent.

The major-industry-group pattern, based on 1960 employment, is dominated by manufacturing at 39 per cent of the total, followed by services at 17 per cent and trade at 15 per cent. Agriculture accounted for the highest percentage of total employment (12.5 per cent) of any of the subareas.

Within the manufacturing sector, motor vehicles, machinery (including electrical), and fabricated metals are the most important industries.

Average value of farm land and buildings per acre in 1959 for each of the three counties in the subarea was far lower than for any other counties in the Area.

Lansing Subarea

This important subarea, comprising the three-county (Clinton, Eaton, and Ingham) Lansing SMSA, exhibits a more diversified and balanced economy. With a total 1960 population of just under 300,000, this subarea recorded the highest 1930-1960 population growth of all subareas in the Area, 73 per cent. The well-balanced economy is exhibited by the 1960 employment pattern for major industry groups (Table 8) showing manufacturing at 27 per cent of the total, services at 26 per cent, trade at 18 per cent, and public administration at 6.5 per cent. This reflects the important employment by government (state capital at Lansing) and Michigan State University at East Lansing.

In the manufacturing sector, however, the picture is far from balanced, with 68 per cent of 1958 manufacturing employment in motor vehicles and parts. Other important groups, far behind motor vehicles, were electrical and nonelectrical machinery, primary metals, and food products.

Northeast Fringe Subarea

This two-county subarea (Gratiot and Shiawassee) is predominantly rural, especially if we consider only the parts lying within the Grand River watershed. As pointed out earlier, the more heavily urbanized areas within the subarea actually lie in the Saginaw River watershed (Alma and St. Louis in Gratiot County, and Owosso and Corunna in Shiawassee County). This subarea is the lowest in total population and in 1930-1960 population growth of the five subareas in the Area.

The 1960 employment pattern by major industry groups (Table 8) is quite similar to that of the West Central Belt Subarea, with manufacturing at 37 per cent, services at 18 per cent, and trade at 17 per cent. Agriculture is a bit lower at 10 per cent, but higher than the three SMSA subareas.

Manufacturing in the subarea is of a more diversified character, with important groups represented by transportation equipment, electrical machinery, inorganic chemicals, and petroleum refining.

In agriculture, the subarea had relatively high average value of farm land and buildings per acre, and the highest proportion of harvested cropland to total land in farms in 1959.

Jackson Subarea

The Jackson SMSA is the only single-county subarea in the Area. It consists only of Jackson County. The economy of the subarea is dominated by the city of Jackson, with a 1960 population of 52,000, about 40 per cent of that of the subarea. Population growth, 1930-1960, at 43 per cent, was lowest for the three SMSA subareas.

The 1960 industry percentage employment pattern is quite similar to that for the Grand Rapids subarea (see Table 8), with manufacturing at 36 per cent, services 19 per cent, and trade 18 per cent of the total.

In manufacturing, the pattern is heavily oriented toward transportation equipment, machinery (including electrical), fabricated metal products, and rubber products.

SECTION B. GRAND RIVER BASIN: POPULATION

I-10. Number and Urban-Rural Classification of Inhabitants

Number of Inhabitants

In 1960, there were approximately 1 million people living in the Grand River Basin Service Area. Nearly 140 of each thousand people in Michigan and over 6 of each thousand people in the United States resided in the Service Area. Over 460,000 people (42 per cent) lived in the Grand Rapids subarea and nearly another 300,000 (27 per cent) in the Lansing subarea; these two subareas accounted for over two-thirds of the Area's population. The distribution of population in the Area is shown in Figure 3.

Between 1900 and 1960, population in the Area increased at a rate almost identical with that of the United States as a whole. However, since population in Michigan grew more rapidly than in the United States during that time period, its growth rate has exceeded that of the Area. As the data in Table 9 indicate, these long-term trends have been altered since 1940. While population increased by 35.7 per cent in the United States between 1940 and 1960, it grew by 45.7 per cent in the Area and 48.8 per cent in Michigan. During the 1950-1960 decade, the growth rate of the Area exceeded that of both the United States and Michigan, as population rose from about 890,000 to nearly 1.1 million people.

The Area's rapid population growth during the decade of the 1950's was not evenly shared by the subareas. In fact, the Area's growth of 23.1 per cent was exceeded only by the Grand Rapids subarea's growth. The lower growth rates for the Lansing and Jackson subareas were nearly identical with that of the state of Michigan*, although they did exceed the rate for the United States. In this decade, as previously, population expansion in the West Central Belt and Northeast Fringe subareas took place more slowly than in Michigan and the United States.

*The rate of population growth in the Jackson Subarea has exceeded that in Michigan in only one decade (1910-1920) since 1900. (See Michigan State Highway Department, Jackson, Michigan State Highway Plan, 1962, p 5.)

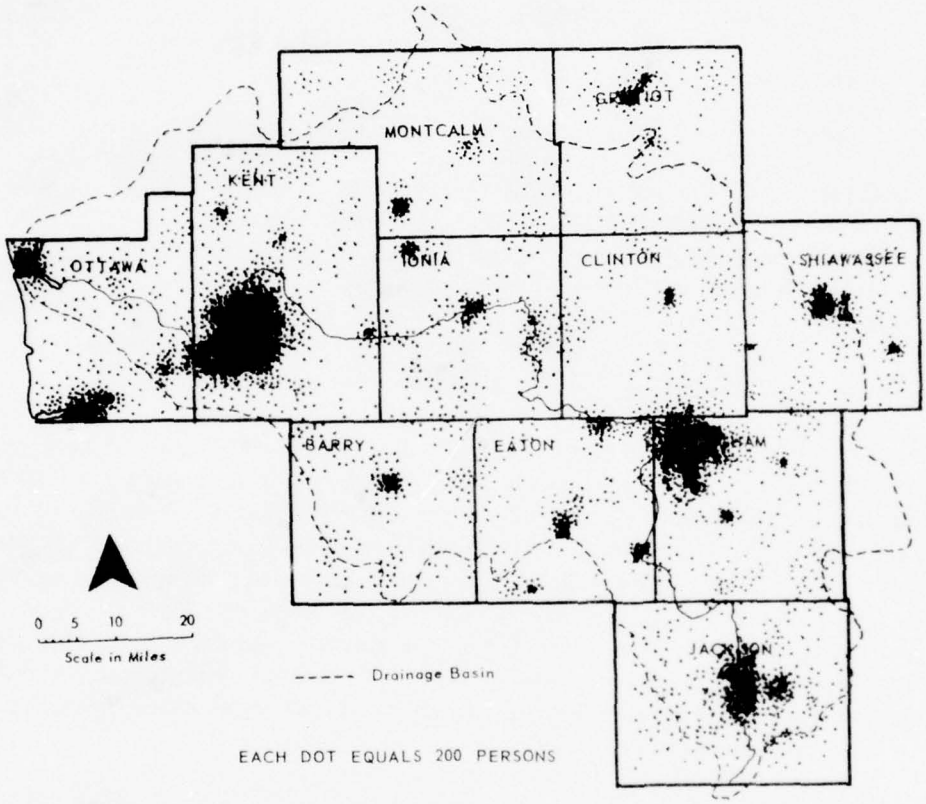

FIGURE 3. POPULATION DISTRIBUTION IN THE AREA, 1960

Source: Derived from U. S. Census of Population, 1960.

TABLE 9. POPULATION GROWTH IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940-1960

Subarea	Thousands of People			Percentage Increase		
	1940	1950	1960	1940-1950	1950-1960	1940-1960
Grand Rapids	306.0	362.0	461.9	18.3	27.6	51.0
West Central Belt	86.9	95.4	110.7	9.7	16.1	27.3
Lansing	191.4	244.2	298.9	27.6	22.4	56.2
Northeast Fringe	73.4	79.4	90.5	8.2	13.9	23.2
Jackson	93.1	107.9	132.0	15.9	22.3	41.8
Area	750.8	888.9	1,094.0	18.4	28.4	45.7
Michigan	5,256.1	6,371.8	7,823.2	21.2	22.8	48.8
United States	132,164.6	151,325.8	179,323.2	14.5	18.5	35.7

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1950, Number of Inhabitants, Michigan, Tables 1 and 7. U. S. Census of Population: 1960, Number of Inhabitants, Michigan, Tables 1 and 6; Number of Inhabitants, United States Summary, Table 2.

Population grew more rapidly during the decade of the 1950's than during the 1940's in each subarea except the Lansing subarea, which experienced a decline from an increase of 27.6 per cent to 22.4 per cent.* In the Grand Rapids subarea, population increased by 27.6 per cent during the 1950's, a substantial increase above the 18.3 per cent rise experienced during the 1940's. This shift in leadership in rate of growth from the Lansing to Grand Rapids subarea is especially significant in light of the fact that the density of population in the Grand Rapids subarea is far in excess of that in the Lansing subarea.

The density of population within the Area is, as one might expect in light of the Area's degree of industrialization, far greater than that found in the United States generally. Table 10 includes data on population density (per square mile) for the years 1940, 1950, and 1960. In 1960, average population density of the Area

*Part of the population increase in the Lansing Subarea between 1940 and 1950 results from a change in census enumerating procedure. In the 1950 Census, college students living away from home were considered residents of the communities in which they were residing while attending college, rather than as persons temporarily absent from their parental homes, as was the practice in 1940. In Population of Michigan Counties - Projections to 1970 by J. F. Thaden, a table is presented in which 1940 figures have been adjusted to include college students at location of residence as in the 1950 and 1960 Census definition. The adjusted 1940 figure reduces the growth in the Lansing Subarea between 1940 and 1950 from 27.6 per cent to 24.1 per cent. The effect on the 1940-1950 growth rate in the other subareas is less than 1.0 per cent.

was 162 persons per square mile, about 25 people per square mile more than in the state of Michigan and a density more than three times as great as that for the United States.

TABLE 10. POPULATION DENSITY OF SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940-1960

Subarea	Population per Square Mile		
	1940	1950	1960
Grand Rapids	214.6	253.9	323.9
West Central Belt	47.3	51.9	60.3
Lansing	112.8	143.9	176.2
Northeast Fringe	66.4	71.8	81.8
Jackson	132.1	153.1	187.2
Area	110.9	131.3	161.6
Michigan	92.2	111.7	137.2
United States	37.2	42.6	50.5

Source: U.S. Census of Population, 1950, Number of Inhabitants, Michigan, Table 5.
U.S. Census of Population, 1960, Number of Inhabitants, Michigan, Tables 6 and 7; Number of Inhabitants, United States Summary, Table 2.

Just as there are wide differences in past population growth rates between the subareas, there are also great differences in population density. In 1960, there were nearly 324 people per square mile in the Grand Rapids subarea* and only 60 people per square mile in the most sparsely populated subarea, the West Central Belt. There were 10 more people per square mile in this subarea than was generally true in the United States.

The most populous subarea, Grand Rapids, also had the greatest population density. While Lansing subarea, with a population of nearly 300,000 in 1960 (27 per cent of the total), was the

*Kent County, part of the Grand Rapids Subarea, was the fifth most densely populated county in the state and had the second highest population density outside of the Detroit area in 1960.

second largest, its population was less concentrated than that in the third most populous subarea, Jackson.* The Northeast Fringe Subarea contained the fewest people (8 per cent of the total) but had approximately 20 more people per square mile than did the fourth largest subarea in population, the West Central Belt.

While population of the Area grew at a lower rate than Michigan between 1940 and 1950, the reverse was true between 1950 and 1960. As discussed above, there were wide disparities in the growth rate experienced by the various subareas. By the same token, there were significant differences in the source of population increase between each of the various subareas.

The net change in population for any area between two dates can be viewed as the sum of the natural increase in population, that is the excess of births over death, plus net migration (defined as immigration minus emigration). Table 11 sets forth the available data on the components of population change for the subareas and for Michigan between 1940 and 1960.

Although rates of natural increase varied among the subareas, net migration has been the factor responsible for most of the variation in the growth patterns of the subareas. With the exception of the Northeast Fringe, net migration was positive in each of the subareas between 1940 and 1960. Detailed data indicate that there was negative net migration in both Gratiot and Shiawassee Counties (the Northeast Fringe) in each of the decades from 1940 to 1960.**

Between 1950 and 1960, net migration accounted for over 20 per cent of the increase in population in the Grand Rapids and Jackson subareas, two of the three fastest growing subareas. However, in the Lansing subarea, which grew at a rate approximately equivalent to that of the Jackson subarea, only 4.7 per cent of the total change in population was accounted for by net migration. In the West Central Belt, a subarea which experienced a 16.1 per cent increase in population between 1950 and 1960 (as compared to

*However, it has been estimated that 200,000 of these people live within 10 miles of the city of Lansing and that 295,000 live within 25 miles of the city. (See Consumers Power Company, Data on Lansing, Michigan, 1960.)

**Net migration was also negative in Ionia County during each of the decades and in Montcalm County between 1940 and 1950. These two counties, when combined with Barry County constitute the West Central Belt Subarea. The positive net migration in Barry County in each decade was sufficient to offset the negative trends in the other two counties, yielding positive net migration for the subarea as a whole.

23.1 per cent for the total Area), only 9.6 per cent of the change resulted from net migration. As mentioned above, net migration was negative in the Northeast Fringe.

TABLE 11. COMPONENTS OF POPULATION CHANGE IN THE SUBAREAS, AREA, AND MICHIGAN, APRIL 1, 1940, TO APRIL 1, 1960

Subarea	Number of Persons: Population Change	Natural Increase[a]	Net Migration	Net Migration as Per Cent of Total Change
	April 1, 1940, to April 1, 1950			
Grand Rapids	56,958	43,214	13,744	24.1
West Central Belt	9,096	8,526	570	6.3
Lansing	47,452	30,823	16,629	35.0
Northeast Fringe	6,134	9,619	-3,485	--[b]
Jackson	15,280	11,027	4,253	27.8
Area	134,920	103,209	31,711	23.5
Michigan	1,106,658	777,597	329,061	29.7
	April 1, 1950, to April 1, 1960			
Grand Rapids	99,863	77,821	22,042	22.1
West Central Belt	15,311	13,838	1,473	9.6
Lansing	54,790	52,198	2,592	4.7
Northeast Fringe	11,062	14,559	-3,497	--[b]
Jackson	24,069	18,552	5,517	22.9
Area	205,095	176,968	28,127	13.7
Michigan	1,451,428	1,289,196	162,232	11.2

(a) Corrected in source for under-registration of births.

(b) Negative net migration.

Source: Thaden, J. F., Population of Michigan Counties, Projection to 1970, Institute for Community Development, Michigan State University, March 1962, pp 24-25.

The fact that total population in the Lansing subarea increased more rapidly between 1940 and 1950 than between 1950 and 1960 results largely from net migration. During the decade of the 1940's, 35 per cent or 16,600 of the 47,000 change in population in the Lansing subarea resulted from net migration. Between 1950 and 1960, total population in the Lansing subarea increased by 54,800, but only 2,600 resulted from net migration. By way of contrast, net migration accounted for between 22 and 28 per cent of the growth during each decade between 1940 and 1960 in the Grand Rapids and Jackson subareas.

TABLE 12. URBAN, RURAL FARM, AND RURAL NONFARM POPULATION IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1960

Subarea	Thousands of People				Percentage Distribution			
	Urban	Rural Farm	Rural Nonfarm	Total	Urban	Rural Farm	Rural Nonfarm	Total
Grand Rapids	341.7	22.6	97.6	461.9	74.0	4.9	21.1	100.0
West Central Belt	28.8	25.2	56.7	110.7	26.0	22.8	51.2	100.0
Lansing	201.2	29.6	68.2	298.9	67.3	9.9	22.8	100.0
Northeast Fringe	38.5	20.0	32.0	90.5	42.5	22.1	35.4	100.0
Jackson	76.0	8.5	47.5	132.0	57.6	6.4	36.0	100.0
Area	686.1	105.9	301.9	1,094.0	62.7	9.7	27.6	100.0
Michigan	5,739.1	440.9	1,643.1	7,823.2	73.4	5.6	21.0	100.0
United States	125,283.8	13,444.9	40,597.0	179,325.7	69.9	7.5	22.6	100.0

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 37 and 91; General Social and Economic Characteristics, United States Summary, Table 65.

The high percentage of urban population in Michigan, compared with that in United States, is a reflection of the fact that relatively few people in the state live on working farms. In 1960, only 5.6 per cent of the total Michigan population lived on rural farms; in the United States the figure was 7.5 per cent. In Michigan 26.6 per cent and in the United States 30.1 per cent of the total population was classified as rural. In Michigan about one out of every five of these noncity dwellers lived on a farm. In the United States one out of every four was a farm resident.

In 1960, people living on working farms accounted for a greater proportion of the population in the Area (9.7 per cent) than in the United States (7.5 per cent) or in Michigan (5.6 per cent). Also relatively more people in the Area lived outside urban areas (37.3 per cent) than in Michigan (26.6 per cent) or the United States (30.1 per cent). The proportion of the rural population in the Area living on farms was slightly greater than in the United States, generally, and hence was substantially above the proportion typical of Michigan.

As is to be expected, the most populous subareas (Grand Rapids and Lansing) were the most highly urbanized. In 1960, only 4.9 per cent of the population in the Grand Rapids subarea lived on farms and 74.0 per cent lived in urban areas; in the Lansing subarea, while 9.9 per cent lived on farms, 67.3 per cent resided in

Urban-Rural Classification of Inhabitants

Unfortunately, completely comparable historical data on classification of place of residence (urban, rural, farm, nonfarm) of the population are not available. While there were minor definitional changes in the basis for classifying urban population between 1950 and 1960, these are not pertinent to Michigan or the Area. The Bureau of the Census definition of urban, applicable to Michigan and the Area, was the same in 1950 and 1960. Urban population was defined to include persons living in places of 2,500 inhabitants or more, the densely settled urban fringe, counties with a population density of 1,500 persons or more per square mile, and unincorporated places of 2,500 inhabitants or more per square mile. The concept of the urbanized area and classification of larger unincorporated places as urban were not used in 1940. Population classified in 1940 as urban is not conceptually comparable to urban population in 1950 and 1960.

The problems with the Census definitions used in dividing rural population into "farm" and "nonfarm" are even more serious. In 1950 and previously, persons were classified as living on farms if they replied positively to the question "Is this house on a farm (or ranch)?" In 1960, the farm population included only persons living in rural territory on places of 10 or more acres from which sales of farm products amounted to $50 or more in 1959 or on places of less than 10 acres from which sales of farm products amounted to $250 or more in 1959. Also, in 1960, all rural population (and only rural population) was classified only as farm or as nonfarm. In previous censuses, farm residence was determined in cities and other territory classified as urban.*

The distribution of the population between the urban, the rural farm, and nonfarm categories for the year 1960 is shown by the data set forth in Table 12. In 1960, nearly 70 per cent of the population in the United States and more than 73 per cent in Michigan lived in urban places. The more rural nature of the Area is indicated by the fact that only 62.7 per cent of its population was designated as urban.

*See U. S. Census of Population, 1960. U. S. Summary, General Social and Economic Characteristics, pp VII-VIII.

urban areas. The third largest subarea, Jackson, had a smaller proportion of the total population living on farms than did the larger Lansing subarea (6.4 per cent compared to 9.9 per cent). The two smaller subareas in terms of population, the West Central Belt and the Northeast Fringe, each had approximately 22 per cent of their population living on farms in 1960, but, significantly, the concentration of population in urban areas in the Northeast Fringe far exceeded that in the West Central Belt. While 42.5 per cent of the population in the Northeast Fringe Subarea lived in urban areas, an additional 35.4 per cent resided on rural nonfarm places. In the West Central Belt, only 26.0 per cent lived in urban areas, but over half (51.2 per cent) of the population had rural nonfarm residences. The unusual nature of the distribution of the population in the West Central Belt is highlighted by comparison with the Lansing subarea, where two-thirds of the population was classified as urban. In the West Central Belt only about one-quarter of the population lived in urban areas. However, in each of these two subareas, approximately 30 per cent of the total rural population resided on farms.

Data pertaining to growth in urban and rural population are set forth in Table 13. Between 1950 and 1960 (the only years for which comparable data are available), rural population showed a very slight decline in the United States. However, in Michigan it increased 11.4 per cent and in the Area 14.8 per cent. The growth in rural population in Michigan and the Area caused total population in these areas to expand more rapidly than in the nation as a whole, for during this decade urban population grew at about the same rate in Michigan (27.5 per cent) and the Area (28.5 per cent) as in the United States (29.3 per cent). Within the Area, urban population grew most rapidly in the densely populated Grand Rapids and Lansing subareas.

As is noted above, the West Central Belt is the least urbanized of the five subareas. It also experienced the lowest growth rate of urban population between 1950 and 1960 and was the only subarea where rural population grew more rapidly (18.8 per cent) than urban population (9.0 per cent). While complete data are not available, the fact that 51.2 per cent of the population in this subarea in 1960 was classified as rural nonfarm strongly suggests that the rapid growth of rural population reflected a growth in rural nonfarm rather than in rural farm population.

TABLE 13. URBAN AND RURAL POPULATION IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	Old Definition				Current Definition				Percentage Increase, 1950-60	
	Thousands of People									
	1940		1950		1950		1960			
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Grand Rapids	195.6	110.4	221.5	150.7	258.0	104.0	341.7	120.2	32.4	15.6
West Central Belt	21.0	65.9	44.1	51.3	26.4	68.9	28.8	81.9	9.0	18.8
Lansing	104.1	87.0	135.5	108.7	157.1	87.0	201.2	97.8	28.0	12.4
Northeast Fringe	27.8	45.6	30.8	48.6	30.8	48.6	38.5	52.0	24.8	7.0
Jackson	49.7	43.5	51.1	56.8	61.3	46.6	76.0	56.0	24.0	20.1
Area	398.4	352.4	472.9	415.9	533.7	355.1	686.1	407.8	28.5	14.8
Michigan	3,454.9	1,801.2	4,099.0	2,272.8	4,503.1	1,868.7	5,739.1	2,084.1	27.5	11.4
United States	74,705.3	57,459.2	90,128.2	61,197.6	96,846.8	54,479.0	125,268.8	54,054.4	29.3	-0.8

Note: Detail may not add to totals due to rounding.

Sources: U. S. Census of Population 1950, Number of Inhabitants, Michigan, Table 5.
U. S. Census of Population 1960, Number of Inhabitants, Michigan, Table 6; Number of Inhabitants, United States Summary, Table 9.

I-11. Households and Household Size*

The average number of people in each household in the United States in 1950 was 3.38. By 1960 the average had declined to 3.29. As may be seen from the data in Table 14, households in Michigan averaged 3.42 persons in 1950. While the average size of household in the nation declined between 1950 and 1960, it remained stable within the state.

TABLE 14. NUMBER OF HOUSEHOLDS AND POPULATION PER HOUSEHOLD FOR THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1950 AND 1960

Subarea	1950		1960	
	Thousands of Households	Population per Household	Thousands of Households	Population per Household
Grand Rapids	106.7	3.31	133.2	3.41
West Central Belt	28.0	3.29	31.8	3.36
Lansing	70.0	3.32	85.1	3.37
Northeast Fringe	23.1	3.38	26.0	3.43
Jackson	30.7	3.26	37.5	3.33
Area	258.6	3.31	313.6	3.39
Michigan	1,791.7	3.42	2,238.6	3.42
United States	42,857.0	3.38	53,021.1	3.29

Note: Detail may not add to totals due to rounding.

Source: U.S. Census of Population: 1950, General Characteristics, Michigan, Tables 22 and 42; General Characteristics, United States Summary, Table 47.
U.S. Census of Population: 1960, General Population Characteristics, Michigan, Table 13; General Population Characteristics, United States Summary, Table 47.

*In 1960 a household consisted of all the persons who occupied a housing unit, whereas in 1950 a household consisted of all the persons who occupied a dwelling unit. The evidence so far available suggests that the use of the housing-unit concept in 1960 instead of the dwelling-unit concept as in 1950 had relatively little effect on the comparability of the statistics for the two dates on the number of households for large areas and for the nation. Any effect which the change in concept may have on comparability can be expected to be great in statistics shown in other reports for small areas, such as city blocks and census tracts. (See U. S. Census of Population, 1960. General Social and Economic Characteristics, United States Summary, page XXIII.)

On average, households in the Area and in each of the subareas were smaller than those in Michigan and in the United States in 1950. By 1960, the picture had changed. In direct contrast to the decline in average size of households in the United States and no change in Michigan between 1950 and 1960, the average size of households in each of the subareas increased during the decade. As a result, by 1960, the average size of households in each of the subareas was above the average for the nation. In spite of the growth, only households in the Northeast Fringe were, on average, larger than those found in Michigan generally.

I-12. Labor Force

Participation

The population and its characteristics constitute the initial base for economic activity within any region. However, only a proportion of the population, determined in part by age and educational attainment characteristics, constitutes a region's labor force. Data pertaining to labor-force participation rates for the subareas, the Area, Michigan, and the United States are given in Table 15.

In 1950, 52.9 per cent of the population, ages 14 years and older, in the United States were found in the labor force. This rate of labor force participation was slightly below that for Michigan (53.6 per cent) and approximately equal to that for the Area (52.8 per cent). Within the Area, participation rates varied substantially in 1950. While the average for the entire Area was 52.8 per cent, the rates in the subareas ranged from 49.8 per cent in Jackson to 54.8 per cent in Grand Rapids.

By 1960, the national participation rate had increased from 52.9 per cent to 54.0 per cent. The rate also increased in Michigan (53.6 per cent to 54.8 per cent). The participation rate for the Area increased even more than the increase experienced in the State and Nation, rising from 52.8 per cent to 55.4 per cent. The increase in participation rates in the Area did not eliminate divergence among the subareas. In 1960, the participation rates in the subareas ranged from 51.8 per cent in the West Central Belt to 56.5 per cent in Grand Rapids.

TABLE 15. LABOR FORCE AND LABOR-FORCE PARTICIPATION RATE IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1950 AND 1960

Subarea	Male		Female		Total	
	Labor Force, thousands	Rate[a], %	Labor Force, thousands	Rate[a], %	Labor Force, thousands	Rate[a], %
			1950			
Grand Rapids	106.0	81.6	40.4	29.5	146.3	54.8
West Central Belt	26.6	74.1	8.3	24.7	34.9	50.2
Lansing	68.8	76.1	26.2	29.0	95.1	52.7
Northeast Fringe	22.2	78.1	7.0	24.4	29.2	51.1
Jackson	29.3	68.5	11.3	29.2	40.6	49.8
Area	252.9	77.3	93.2	28.4	346.0	52.8
Michigan	1,887.9	79.7	642.1	27.3	2,530.1	53.6
United States	42,768.1	78.0	16,535.6	28.9	59,303.7	52.9
			1960			
Grand Rapids	119.4	80.2	56.3	34.8	175.6	56.5
West Central Belt	28.0	71.4	11.6	31.2	39.6	51.8
Lansing	77.9	77.5	37.7	36.0	115.6	56.3
Northeast Fringe	23.2	77.4	10.3	32.9	33.4	54.5
Jackson	33.5	70.9	15.4	34.6	48.9	53.3
Area	281.9		131.2	34.5	413.1	55.4
Michigan	2,037.4	77.7	892.9	32.8	2,930.3	54.8
United States	45,762.7	74.6	22,381.4	34.5	68,144.1	54.0

(a) Persons in civilian labor force as per cent of population 14 years and over.

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 27 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, United States Summary, Table 83; General Social and Economic Characteristics, Michigan, Tables 52 and 83.

Employment and Unemployment

The labor force includes both people actively employed and those out of work, but seeking employment. Data pertaining to unemployment rates are shown in Table 16. In 1950, only 3.9 per cent of the labor force in the Area was unemployed. This low level

TABLE 16. UNEMPLOYMENT IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1950 AND 1960

Subarea	Thousands of Unemployed Persons						Unemployed Persons, per cent of civilian labor force					
	1950			1960			1950			1960		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Grand Rapids	3.4	1.7	5.1	5.8	3.0	8.8	3.2	4.1	3.5	4.8	5.4	5.0
West Central Belt	0.8	0.4	1.2	1.3	0.6	1.9	3.2	4.8	3.5	4.8	5.0	4.8
Lansing	3.0	1.2	4.1	3.8	1.6	5.3	4.3	4.4	4.3	4.8	4.2	4.6
Northeast Fringe	0.6	0.3	0.9	1.4	0.6	2.0	2.9	4.1	3.2	6.1	5.4	5.9
Jackson	1.7	0.6	2.3	1.9	1.2	3.1	5.7	5.7	5.7	5.8	7.7	6.4
Area	9.5	4.1	13.7	14.2	6.9	21.1	3.8	4.5	3.9	5.0	5.3	5.1
Michigan	101.9	34.6	136.5	139.4	64.1	203.5	5.4	5.4	5.4	6.8	7.2	6.9
United States	2,096.4	757.9	2,854.3	2,295.7	1,209.1	3,504.8	4.9	4.6	4.8	5.0	5.4	5.1

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 27 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 52 and 83; General Social and Economic Characteristics, United States Summary, Table 83.

of employment was in marked contrast to the 5.4 per cent rate in Michigan and 4.8 per cent in the nation. In fact, only the Jackson subarea had an unemployment rate greater than that of either Michigan or the United States in that year.

By 1960, the picture had changed substantially. The rate for the Area rose to equal that for the nation, although it did not reach the level for Michigan. In 1960, unemployment rates in both the Jackson and Northeast Fringe subareas exceeded the national rate, but none of the subareas reached the 6.9 per cent rate experienced by the entire state of Michigan. The most dramatic shift for any single subarea occurred in the Northeast Fringe, where the rate went from 3.2 per cent to 5.9 per cent. In 1950, this subarea had the lowest unemployment rate within the total service area; by 1960, only the Jackson subarea had a higher rate. The smallest rise occurred in the Lansing subarea, which had a rate of 4.3 per cent in 1950; by 1960, this rate had risen only to 4.6 per cent, doubtless reflecting the importance of government and educational services in the employment picture in this subarea.*

Occupations

In 1950, approximately 332,000 of the people living in the Area were employed.** By 1960 employment had risen to 392,000. Analysis of available census data (set forth in Tables 17 through 20 yields a profile of the occupations in which these people were employed.***

The occupational pattern of employment in Michigan and the Area in 1960 was generally comparable to the pattern throughout

*According to one estimate, unemployment in the Lansing area averaged 4.4 per cent, as compared with a state average of 6.3 per cent between 1950 and 1960, as a result of the stability of government jobs. See Michigan State Highway Department, Lansing Area Trunkline Plan, September, 1961, Section I.

**Data on occupations and employment by industry are drawn from the Census of Population and therefore pertain to place of residence rather than place of work.

***Because occupation data are derived from questioning the employees rather than employers, a small portion of respondents do not report their occupation. In 1950, 1.5 per cent and, in 1960, 3.7 per cent of the employed residents of the Area did not report their occupations. In Michigan, 1.3 per cent and 4.3 per cent and, in the United States, 1.3 per cent and 4.9 per cent did not report occupation in 1950 and 1960, respectively. In the subsequent analysis of the distribution of employment by occupations, those who did not report their occupation have been excluded, and the percentages relate only to those who reported occupation.

TABLE 17. EMPLOYED PERSONS[a] BY MAJOR OCCUPATION GROUP IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1950

Occupational Group	Thousands of Employed Persons							
	Subarea							
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson	Area	Michigan	United States
Professional, technical, and kindred workers	11.6	2.3	10.1	1.9	3.4	29.3	202.0	4,910.2
Managers, officials, and proprietors, except farm	12.6	2.3	6.0	2.2	3.3	26.4	189.3	5,018.0
Clerical and kindred workers	17.2	2.5	12.8	2.5	4.6	39.5	295.4	6,895.3
Sales workers	11.9	1.9	7.3	1.7	3.0	25.8	166.7	3,926.8
Craftsmen, foremen, and kindred workers	23.4	4.2	12.9	3.8	6.3	50.6	392.3	7,783.0
Operatives and kindred workers	37.6	7.7	19.5	6.7	9.4	80.9	619.2	11,140.2
Private household workers	2.4	0.7	1.3	0.5	0.7	5.6	40.1	1,407.8
Service workers, except private household	9.5	2.0	7.7	1.5	3.2	24.0	181.9	4,286.5
Farmers and farm managers	5.4	6.2	6.3	4.6	1.7	24.2	113.4	4,308.5
Farm laborers and farm foremen	2.2	2.0	2.0	1.3	0.7	8.3	42.5	2,400.3
Laborers, except farm and mine	5.7	1.4	3.0	1.2	1.4	12.7	118.7	3,430.6
Total employed	139.6	33.2	89.0	27.8	37.8	327.3	2,361.5	55,507.3

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting occupation in the census survey.

Source: U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 28 and 43; General Characteristics, United States Summary, Table 76.

TABLE 18. PERCENTAGE DISTRIBUTION OF EMPLOYED PERSONS[a] BY MAJOR OCCUPATION GROUP FOR THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1950

Occupation Group	Subarea					Area	Michigan	United States
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson			
Professional, technical, and kindred workers	8.3	6.8	11.4	6.7	9.0	8.9	8.6	8.9
Managers, officials, and proprietors, except farm	9.0	7.0	6.7	7.8	8.8	8.1	8.0	9.0
Clerical and kindred workers	12.3	7.6	14.3	8.9	12.1	12.1	12.5	12.4
Sales workers	8.5	5.7	8.3	6.2	7.9	7.9	7.1	7.1
Craftsmen, foremen, and kindred workers	16.8	12.7	14.6	13.6	16.6	15.5	16.6	14.0
Operatives and kindred workers	27.0	23.2	21.9	24.0	24.9	24.7	26.2	20.1
Private household workers	1.7	2.1	1.5	1.7	1.9	1.7	1.7	2.5
Service workers, except private household	6.8	6.1	8.6	5.5	8.5	7.3	7.7	7.7
Farmers and farm managers	3.9	18.7	7.1	16.4	4.6	7.4	4.8	7.8
Farm laborers and farm foremen	1.6	6.0	2.3	4.8	1.9	2.5	1.8	4.3
Laborers, except farm and mine	4.1	4.1	3.3	4.4	3.8	3.9	5.0	6.2
Total employed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting occupation in the census survey.

Sources: U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 28 and 43; General Characteristics, United States Summary, Table 76.

TABLE 19. EMPLOYED PERSONS[a] BY MAJOR OCCUPATION GROUP IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1960

Occupation Group	Thousands of Employed Persons							
	Subarea							
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson	Area	Michigan	United States
Professional, technical, and kindred workers	17.7	3.2	14.9	2.8	4.9	43.5	312.6	7,232.4
Managers, officials, and proprietors, except farm	13.6	2.3	8.0	2.1	3.5	29.6	200.0	5,409.5
Clerical and kindred workers	23.2	3.4	18.0	3.7	6.4	54.9	379.6	9,306.9
Sales workers	14.4	2.1	8.4	1.9	3.3	30.1	202.4	4,639.0
Craftsmen, foremen, and kindred workers	26.4	5.0	15.3	4.6	6.9	58.1	420.1	8,741.3
Operative and kindred workers	39.4	9.9	19.2	8.0	10.5	87.1	606.4	11,897.6
Private household workers	3.4	0.9	2.4	0.9	0.8	8.5	58.7	1,725.8
Service workers, except private household	12.8	2.8	10.6	2.4	4.3	33.0	236.4	5,445.0
Farmers and farm managers	3.0	3.3	3.8	2.3	0.9	13.5	60.1	2,505.7
Farm laborers and farm foremen	1.5	1.2	1.5	0.6	0.6	5.5	25.2	1,444.8
Laborers, except farm and mine	6.2	1.6	3.3	1.2	1.6	13.9	109.3	3,107.5
Total employed	161.7	35.9	105.4	30.7	43.9	377.6	2,610.8	61,455.6

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting occupation in the census survey.

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, United States Summary, Table 87; General Social and Economic Characteristics, Michigan, Tables 57 and 84.

TABLE 20. PERCENTAGE DISTRIBUTION OF EMPLOYED PERSONS[a] BY MAJOR OCCUPATION GROUP FOR THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1960

Occupation Group	Subarea: Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson	Area	Michigan	United States
Professional, technical, and kindred workers	11.0	8.9	14.1	9.1	11.2	11.5	12.0	11.8
Managers, officials, and proprietors, except farm	8.4	6.6	7.6	7.0	7.9	7.8	7.7	8.8
Clerical and kindred workers	14.4	9.6	17.1	12.2	14.7	14.5	14.5	15.1
Sales workers	8.9	5.9	7.9	6.3	7.5	8.0	7.7	7.5
Craftsmen, foremen, and kindred workers	16.3	13.8	14.5	15.0	15.7	15.4	16.1	14.2
Operatives and kindred workers	24.4	27.7	18.2	26.1	24.0	23.1	23.2	19.4
Private household workers	2.1	2.5	2.3	2.9	1.9	2.2	2.2	2.8
Service workers, except private household	7.9	7.9	10.1	7.8	9.8	8.7	9.1	8.9
Farmers and farm managers	1.9	9.2	3.6	7.6	2.1	3.6	2.3	4.1
Farm laborers and farm foremen	.9	3.4	1.5	2.1	1.4	1.5	1.0	2.4
Laborers, except farm and mine	3.8	4.5	3.1	3.9	3.8	3.7	4.2	5.0
Total employed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting occupation in the census survey.

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 57 and 84; General Social and Economic Characteristics, United States Summary, Table 87.

the United States, with some noteworthy exceptions. Craftsmen accounted for 14.2 per cent of employment in the United States, 15.4 per cent in the Area, 16.1 per cent in Michigan; operatives, 19.4 per cent in the United States, 23.2 per cent in Michigan, and 23.1 per cent in the Area; farmers, 4.1 per cent nationally, 3.6 per cent in the Area, and only 2.3 per cent in Michigan; and laborers, 5.0 per cent in the United States, 4.2 per cent in Michigan Michigan, and only 3.7 per cent in the Area.

There were many significant changes in the pattern of occupations in the United States between 1950 and 1960. Most of these changes were also evidenced in Michigan and the Area. During the decade of the 1950's, the fastest growing occupations, relative to total employment in the United States, were professional and technical, clerical, sales workers, private household, and service workers. Managers and officials, operatives, nonfarm laborers, farmers, and farm laborers all showed relative declines, with the last three groups evidencing absolute declines in the United States and Michigan. Farmers and farm laborers declined absolutely in the Area as well.

While the *distribution of occupations* within the Area generally followed that of the United States, there were significant differences among the subareas. In the Grand Rapids subarea, in 1960, sales workers, craftsmen, and operatives each accounted for relatively more employment than in the United States or Michigan. This was particularly true for operatives, who accounted for 19.4 per cent of national employment and 24.4 per cent of the employment of those living in the Grand Rapids subarea. Those employed as farmers and farm managers, farm laborers, and nonfarm laborers accounted for a disproportionately small share of employment in the Grand Rapids subarea. Between 1950 and 1960, the trends among various occupations in the Grand Rapids subarea generally followed those of the United States.

In 1960, the West Central Belt subarea was characterized by a disproportionately high percentage of employment in the operatives group (27.7 per cent as compared to 19.4 per cent in the nation and 23.3 per cent in Michigan) and in the farmers and farm managers group, which accounted for 9.2 per cent of employment in this subarea as compared to 4.1 per cent in the United States and 2.3 per cent in Michigan. Significantly, while those employed as farmers and farm managers accounted for a disproportionately high percentage of employment, those employed as farm laborers

accounted for a share more closely related to that in the nation. This, of course, is a reflection of the extent to which the farms in the West Central Belt are characterized as sole proprietorships or partnerships rather than large corporate enterprises.

As a result of the disproportionately large employment in the farmers and farm managers group and in the operatives classification, most other occupational groups account for a smaller percentage of employment in the West Central Belt subarea than in the United States or in Michigan. Between 1950 and 1960, the trends in relative share of employment generally followed those for the United States and Michigan, with the exception of operatives and laborers.

The outstanding feature of those employees living in the Lansing subarea is that disproportionately large segments are in the professional and technical and in the clerical occupations. In 1960, 14.1 per cent of those living in this subarea were professional and technical workers. In the same year, these occupations accounted for 12.0 per cent and 11.8 per cent of employment, respectively, in Michigan and the nation. Clerical workers accounted for 15.1 per cent of national employment and 14.5 per cent of Michigan employment in 1960; 17.1 per cent of those in the Lansing subarea earned their living from clerical jobs. Finally, this subarea is characterized by the relatively low proportion of total employment in the laborers group.

In the Lansing subarea, as in most of the others, the trends in relative share of employment between 1950 and 1960 generally parallel those for the United States and for Michigan. There are two exceptions. In the United States and Michigan, the share of total employment accounted for by managers, officials, and proprietors declined between 1950 and 1960. In the Lansing subarea, the share of this group rose from 6.7 per cent to 7.6 per cent over the decade. In the United States and Michigan, sales workers accounted for a greater share of employment in 1960 than in 1950. In the Lansing subarea the share accounted for by this group declined from 8.3 per cent to 7.9 per cent over the decade.

The Northeast Fringe subarea was characterized in 1960 by disproportionately heavy employment in the operatives group (26.1 per cent in the subarea as compared to 23.2 per cent in Michigan and 19.4 per cent in the United States) and in farmers and farm managers (7.4 per cent in the subarea, 2.3 per cent in

Michigan and 4.1 per cent in the nation). On the other hand, the share of total employment accounted for by laborers in the subarea was substantially below that for the United States (3.9 per cent in the subarea, 5.0 per cent in the nation).

The relative shares of employment in each of the various occupational groups in this subarea generally followed the national pattern between 1950 and 1960 with the exception of operatives. This group declined relative to total employment in the United States and in Michigan between 1950 and 1960, but rose from 24.0 per cent to 26.1 per cent of employment in the subarea during the same period.

The major feature of the occupational employment pattern in the Jackson subarea, in 1960, differentiating it from the United States, was a disproportionately high percentage of employees in the operatives group (24.0 per cent) and a disproportionately low segment employed as farmers and farm managers (2.1 per cent).

While those employed as sales workers increased relative to total employment in the United States and in Michigan between 1950 and 1960, the share in the Jackson subarea declined from 7.9 per cent to 7.5 per cent. Similarly, while craftsmen accounted for a slightly larger share of total employment in the United States in 1960 than in 1950 (although the share declined in Michigan), this group fell relative to total employment in the Jackson subarea. In 1950, 16.6 per cent of all employees were classified as craftsmen but, by 1960, this group had fallen to 15.7 per cent of the total.

SECTION C. GRAND RIVER BASIN: EMPLOYMENT BY MAJOR INDUSTRY GROUP (1940-1960)

Employment and the percentage distribution of employment among ten major industrial groupings is set forth for Michigan, the United States, the Area, and the subareas for the years 1960, 1950, and 1940 in Tables 21 through 26.* Confining the analysis initially to the relationship between the pattern of employment by major industry groups in the Area, Michigan, and the United States, most noteworthy is the disproportionately heavy concentration of

*These data, drawn from the Bureau of Census, Census of Population, refer to place of residence.

TABLE 21. EMPLOYED PERSONS[a] BY MAJOR INDUSTRY GROUP IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1960

Industry Group	Thousands of Employed Persons							
	Subarea							
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson	Area	Michigan	United States
Agriculture, forestry, and fisheries	5.2	4.7	5.7	3.1	1.7	20.3	93.7	4,349.9
Mining	0.3	0.1	0.1	0.1	0.1	0.8	15.3	654.0
Construction	8.8	1.7	6.6	1.3	1.9	20.4	125.6	3,815.9
Manufacturing	62.6	14.6	29.5	11.6	16.3	134.7	1,035.9	17,513.1
Transportation	6.1	0.7	2.3	1.4	1.7	12.2	86.7	2,739.9
Communications, utilities, and sanitary service	3.8	0.7	2.6	0.9	2.6	10.5	68.9	1,718.2
Wholesale and retail trade	32.7	5.8	19.6	5.2	8.3	71.7	484.0	11,792.6
Finance, insurance, and real estate	6.3	0.8	4.3	0.7	1.3	13.4	89.6	2,694.6
Services	32.8	6.3	28.4	5.8	8.5	81.8	542.8	13,549.9
Public administration	4.2	1.1	7.2	0.9	1.8	15.2	94.8	3,202.9
Total	162.9	36.5	106.5	30.9	44.3	381.0	2,637.3	62,031.2

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting industry in the census survey.

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 83; General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 22. PERCENTAGE DISTRIBUTION OF EMPLOYED PERSONS[a] BY MAJOR INDUSTRY GROUP FOR THE SUB-AREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1960

Industry Group	Subarea					Area	Michigan	United States
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson			
Agriculture, forestry, and fisheries	3.2	12.9	5.3	9.9	3.8	5.3	3.5	7.0
Mining	0.2	0.2	0.1	0.2	0.3	0.2	0.6	1.1
Construction	5.4	4.8	6.2	4.3	4.3	5.4	4.8	6.2
Manufacturing	38.4	40.2	27.7	37.6	36.7	35.3	39.3	28.2
Transportation	3.8	1.8	2.2	4.4	3.9	3.2	3.3	4.4
Communications, utilities, and sanitary service	2.3	1.9	2.5	2.8	5.8	2.8	2.6	2.8
Wholesale and retail trade	20.1	15.9	18.4	16.9	18.8	18.8	18.3	19.0
Finance, insurance, and real estate	3.9	2.1	4.1	2.3	2.9	3.5	3.4	4.3
Services	20.1	17.2	26.7	18.8	19.3	21.5	20.6	21.8
Public administration	2.6	3.1	6.8	2.8	4.2	4.0	3.6	5.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting industry in the census survey.

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 83; General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 23. EMPLOYED PERSONS[(a)] BY MAJOR INDUSTRY GROUP IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1950

Industry Group	Thousands of Employed Persons							
	Subarea							
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson	Area	Michigan	United States
Agriculture, forestry, and fisheries	8.0	8.3	8.6	6.0	2.5	33.4	161.6	7,033.6
Mining	0.3	0.1	0.1	0.1	--	0.6	15.4	931.0
Construction	7.5	1.5	4.9	1.1	1.6	16.7	118.3	3,458.0
Manufacturing	56.1	10.7	28.4	8.6	13.6	117.5	981.3	14,685.5
Transportation	6.0	0.7	2.2	1.5	2.2	12.6	89.0	2,954.0
Communications, utilities, and sanitary services	3.4	0.7	2.0	0.7	1.9	8.7	63.6	1,495.9
Wholesale and retail trade	28.2	4.9	16.6	4.8	7.3	61.7	418.3	10,507.3
Finance, insurance, and real estate	4.4	0.5	3.0	0.4	0.8	9.2	64.4	1,919.6
Services	22.4	4.8	17.6	3.9	6.0	54.6	374.7	10,092.6
Public administration	3.2	1.0	5.4	0.6	1.6	11.9	73.7	2,514.5
Total	139.4	33.2	88.8	27.8	37.7	326.9	2,360.3	55,591.9

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting industry in the census survey.

Source: U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 24. PERCENTAGE DISTRIBUTION OF EMPLOYED PERSONS[a] BY MAJOR INDUSTRY GROUP FOR THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1950

Industry Group	Subarea					Area	Michigan	United States
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson			
Agriculture, forestry and fisheries	5.8	25.0	9.7	21.5	6.7	10.2	6.8	12.6
Mining	0.2	0.3	0.1	0.3	0.1	0.2	0.7	1.7
Construction	5.4	4.6	5.5	4.1	4.3	5.1	5.0	6.2
Manufacturing	40.2	32.3	32.0	31.0	36.1	35.9	41.6	26.4
Transportation	4.3	2.0	2.5	5.3	6.0	3.9	3.8	5.3
Communications, utilities, and sanitary services	2.4	2.0	2.3	2.6	5.1	2.7	2.7	2.7
Wholesale and retail trade	20.2	14.8	18.6	17.4	19.3	18.9	17.7	18.9
Finance, insurance, and real estate	3.1	1.4	3.4	1.6	2.3	2.8	2.7	3.5
Services	16.1	14.5	19.8	13.9	15.8	16.7	15.9	18.2
Public administration	2.3	3.1	6.1	2.3	4.3	3.6	3.1	4.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting industry in the census survey.

Source: U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 25. EMPLOYED PERSONS[a] BY MAJOR INDUSTRY GROUP IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940

Industry Group	Thousands of Employed Persons							
	Subarea							
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson	Area	Michigan	United States
Agriculture, forestry, and fisheries	10.6	11.4	11.4	8.3	3.5	45.2	216.7	8,559.1
Mining	0.8	0.1	0.1	0.2	--	1.1	15.8	918.9
Construction	4.6	1.1	2.8	0.8	1.1	10.4	73.9	2,087.6
Manufacturing	38.4	5.7	18.8	4.4	9.4	76.8	703.8	10,670.1
Transportation	4.6	0.5	1.4	1.3	2.2	10.1	63.3	2,193.8
Communications, utilities, and sanitary services	2.4	0.4	1.3	0.5	1.4	6.0	37.4	949.5
Wholesale and retail trade	19.6	3.3	11.1	3.4	5.2	42.7	292.3	7,497.8
Finance, insurance, and real estate	3.1	0.4	2.0	0.3	0.8	6.6	48.2	1,474.7
Services	18.5	4.0	11.7	3.3	4.9	42.4	296.1	8,574.2
Public administration	2.6	0.7	4.5	0.5	1.1	9.5	48.9	1,415.3
Total	105.2	27.6	65.1	23.1	29.6	250.6	1,796.5	44,340.8

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting industry in the census survey.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 19 and 23.
U. S. Census of Population: 1960, General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 26. PERCENTAGE DISTRIBUTION OF EMPLOYED PERSONS[a] BY MAJOR INDUSTRY GROUP FOR THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940

Industry Group	Subarea					Area	Michigan	United States
	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson			
Agriculture, forestry, and fisheries	10.1	41.2	17.5	36.0	11.8	18.0	12.1	19.3
Mining	0.8	0.3	0.1	0.8	--	0.5	0.9	2.1
Construction	4.3	4.0	4.4	3.5	3.6	4.2	4.1	4.7
Manufacturing	36.5	20.6	28.9	19.0	31.8	30.6	39.1	24.1
Transportation	4.4	1.8	2.2	5.8	7.3	4.0	3.5	4.9
Communications, utilities, and sanitary services	2.2	1.5	2.0	2.2	4.9	2.4	2.1	2.2
Wholesale and retail trade	18.6	12.1	17.0	14.9	17.7	17.0	16.3	16.9
Finance, insurance, and real estate	3.0	1.3	3.1	1.3	2.6	2.6	2.7	3.3
Services	17.6	14.6	17.9	14.4	16.4	16.9	16.5	19.3
Public administration	2.5	2.6	6.9	2.1	3.9	3.8	2.7	3.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: Detail may not add to totals due to rounding.

(a) Excludes employed persons not reporting industry in the census survey.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 19 and 23.
U. S. Census of Population: 1960, General Social and Economic Characteristics, United States Summary, Table 92.

employment in manufacturing in Michigan and the Area, as compared with that in the United States.* In 1960, 28.2 per cent of total employment was in manufacturing in the United States, as contrasted with 39.3 per cent in Michigan and 35.3 per cent in the Area. The same pattern existed in 1950 and 1940. The data also indicate that agriculture is, and has been, less significant in the employment picture in Michigan than in the United States. The same is true of the Area but to a lesser degree. In 1940, 19.3 per cent of total employment in the United States was in agriculture** as compared with 12.1 per cent and 18.0 per cent for Michigan and for the Area. By 1960, only 7.0 per cent of the total national employment was in agriculture, while 3.5 per cent and 5.3 per cent of total employment was classified in this industry for Michigan and for the Area, respectively.

Similarly, the importance of mining in both Michigan and in the Area has been less than in the United States. Between 1940 and 1960, the share of total employment accounted for by mining in the United States declined from 2.1 per cent to 1.1 per cent. In Michigan and in the Area there was also a decline. This industry accounted for only 0.9 per cent of total employment in Michigan in 1940 and only 0.6 per cent in 1960, compared with 0.5 per cent and 0.2 per cent, respectively, in the Area.

While the relative preponderance of manufacturing has been the outstanding characteristic of the employment pattern of Michigan and the Area, some of the employment trends in other industries are significant, especially as they may cast light on likely future growth. The proportion of employment accounted for by construction trades rose in the United States from 1940 to 1950 and then remained stable at 6.2 per cent. In Michigan, a similar increase was experienced between 1940 and 1950, but there was a slight decline (from 5.0 per cent to 4.8 per cent) between

*Because employment-by-industry data are derived from questioning employees rather than employers, a small proportion of respondents do not report the industry in which they are employed. In 1950, 1.7 per cent and, in 1960, 2.8 per cent of the employed residents of the Area did not report their industry of employment. In Michigan, 1.3 and 3.2 per cent and, in the United States, 1.5 and 4.0 per cent did not report industry in 1950 and 1960, respectively. In the subsequent analysis of the distribution of employment by industry, those who did not report their occupation have been excluded and the percentage relates only to those who reported industry of employment.

**Technically these data refer to agriculture, forestry, and fisheries. However, forestry and fisheries account for a very small proportion of the total. In 1960, these two industries accounted for only 0.03 per cent of employment in the Area, 0.06 per cent in Michigan, and 0.15 per cent in the United States.

1950 and 1960. Throughout the 20-year period under consideration, the proportion of total employment in construction continued to rise in the Area although, even by 1960, this activity accounted for relatively less employment than in the United States.

While the share of total employment accounted for by manufacturing activities rose steadily in the United States (from 24.1 to 28.2 per cent) between 1940 and 1960, the pattern was dissimilar in Michigan and the Area. In both of these regions, the share of employment in manufacturing activities increased between 1940 and 1950 and then declined slightly between 1950 and 1960.

The relative share of employment in transportation, nationally, rose between 1940 and 1950 and then declined to the point where the share in 1960 was below that for 1940. A similar pattern was followed in Michigan (although the absolute share of transportation was below that for the United States). In contrast, while the share of employment in transportation rose nationally and in Michigan between 1940 and 1950, it declined very slightly in the Area (from 4.0 per cent to 3.9 per cent) and then paralleled to the national and Michigan decline between 1950 and 1960.

Communications, utilities and sanitary services rose relative to total employment in the United States from 1940 to 1950 and again from 1950 to 1960. In Michigan there was a parallel rise between 1940 and 1950 but a very slight decline between 1950 and 1960. The pattern in the Area, in terms of trend as well as level, has closely followed that of the United States.

The proportion of total employment accounted for by wholesale and retail trade increased steadily in the United States and Michigan between 1940 and 1960. It rose in the Area between 1940 and 1950, but declined slightly between 1950 and 1960.

Similarly, the proportion of employment accounted for by finance, insurance, and real estate increased in the United States, Michigan, and the Area between 1940 and 1960. There was one exception: in Michigan, between 1940 and 1950, the share of total employment in this category remained stable.

The share of employment in services in the United States declined between 1940 and 1950, and then rose between 1950 and 1960. Similar patterns existed for both Michigan and the Area.

The relative employment in public administration in the United States rose from 3.2 per cent to 5.2 per cent between 1940 and 1960. This activity also increased in importance in Michigan during the same time period, rising from a level of 2.7 per cent in 1940 to 3.6 per cent in 1960. In contradistinction, the share of employment in this category in the Area declined from 3.8 per cent to 3.6 per cent between 1940 and 1950 but then recovered, rising from 3.6 per cent to 4.0 per cent in 1960. In 1960, public administration was more important as an employer in the United States than in Michigan. There was a slightly greater percentage of people employed in this industry in the Area in 1960 than in Michigan, but at that time, as well as in 1950, the over-all share of employment within the Area accounted for by public administration was less than in the United States.

There are three major characteristics which describe the distribution of employment by industry among the five subareas. First, the Grand Rapids subarea has the largest total population and total employment; it also accounted for the greatest number of employees in each of the major industries except agriculture and public administration in 1960, 1950, and 1940. Second, in 1940, the greatest concentration (in terms of total employment) in agriculture was in the West Central Belt and Lansing subareas, each with 11,400 employees in this industry. In 1950 and in 1960, even though agriculture was relatively more important in the West Central Belt and the Northeast Fringe, the Lansing subarea accounted for the greatest absolute number of employees in this industry. The third outstanding characteristic is the concentration of public administration both absolutely and relative to total employment in the Lansing Subarea. This is of course a reflection of the fact that the city of Lansing is the State capital.

While the pattern of relative employment in each of the subareas has generally tended to follow that for the state of Michigan and the United States since 1940, there are certain significant exceptions. Among these is the degree to which agriculture has become progressively less important in the West Central Belt and Northeast Fringe Subareas. In 1940, this industry accounted for 41.2 per cent of total employment in the West Central Belt subarea and 36.0 per cent in the Northeast Fringe subarea. By 1960 it had declined to 12.9 per cent and 9.9 per cent in each of these subareas, respectively. This relative decline has been offset in each of these subareas, in large measure, by the relative increase in

importance of manufacturing. In the West Central Belt Subarea, manufacturing employment rose from 20.6 per cent in 1940 to 40.2 per cent of total employment in 1960. In the Northeast Fringe, manufacturing accounted for only 19.0 per cent of total employment in 1940, but rose to 37.6 per cent in 1960. The share of employment in manufacturing in Michigan over the same time period was relatively stable; in the United States it grew some, but not to the extent experienced in these two subareas.

It was noted above that manufacturing in the Area accounted for a larger proportion of total employment than in the United States, but a percentage generally representative of the state of Michigan. This relative importance in manufacturing persisted within each of the subareas in 1960, with the exception of the Lansing subarea. In that subarea, manufacturing accounted for only 27.7 per cent of total employment while it accounted for 35.3 per cent for the Area. The relative unimportance of manufacturing in this subarea is a reflection of the high proportion of total employment accounted for by public administration and also by services. In 1960, services accounted for 20.6 per cent of total employment in Michigan, 21.8 per cent of the total for the United States, and 21.5 per cent for the Area. In the Lansing subarea this industry accounted for 26.7 per cent of those employed there.

The general decline in the relative importance of agriculture as a source of employment in each of the subareas has, to a degree, been offset by the growth in employment of services. This was particularly true between 1950 and 1960, when services grew from 16.1 per cent to 20.1 per cent in the Grand Rapids subarea, from 14.5 per cent to 17.2 per cent in the West Central Belt subarea, from 19.8 per cent to 26.7 per cent in the Lansing subarea, from 13.9 per cent to 18.8 per cent in the Northeast Fringe subarea, and from 15.8 per cent to 19.3 per cent in the Jackson subarea.

Finally, the pattern of growth and the relative importance of public administration among the various subareas has been in sharp contrast to the pattern in the United States and, although to a lesser degree, to the pattern for the state of Michigan. Between 1940 and 1960, the share of total employment accounted for by public administration grew in four of the five subareas. However, the growth led to an increase in per cent of total employment ranging from 0.1 per cent in the Grand Rapids subarea to 0.7 per cent in the Northeast Fringe. There was a decline of 0.1 per cent

of total employment in public administration in the Lansing Subarea, the region with the heaviest concentration of employment in public administration. By way of contrast, public administration accounted for 0.9 per cent more of total employment in Michigan in 1960 than in 1940 and for 2.0 per cent more in the United States in 1960 than in 1940.

I-13. Employment and Distribution of Employees Within the Area

This section is concerned with a somewhat more detailed discussion of total employment and employment in each of the major industry classes, including a separate table for each. While many of the data duplicate those given in Tables 21 through 26 the picture for each industry is covered in more detail, showing percentage distribution amongst the subareas in the Area, together with percentage growth for the subareas, Area, Michigan, and the United States for the periods 1940-1950 and 1950-1960.

Total Employment

Since 1940, total employment in the Area has grown more rapidly than in the United States, as shown by data in Table 27. Between 1940 and 1950, it grew at about the same rate as in Michigan and faster than the nation, but between 1950 and 1960, the rate of growth in the Area was significantly greater than in Michigan and the United States.

Growth of employment in the Area has not been equally distributed among the subareas. Employment grew faster in the Grand Rapids subarea (the largest in terms of employment) than in the Area between 1940 and 1950 and also between 1950 and 1960; its share of Area employment remained about constant between 1940 and 1960 at about 42 per cent. A similar pattern occurred in the Lansing subarea. This subarea accounted for 25.9 per cent of total Area employment in 1940 and 28.1 per cent in 1960. Its growth in both decades was highest of all the subareas. Between 1940 and 1950, employment in the Jackson subarea grew less rapidly than employment in the Area, and, while the growth was greater than that in the United States, the 26.7 per cent increase in this subarea was less than that experienced in Michigan. This

TABLE 27. TOTAL EMPLOYMENT[a] IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	106,681	41.9	141,259	42.5	166,822	42.5	32.4	18.1
West Central Belt	28,112	11.0	33,647	10.1	37,660	9.6	19.7	11.9
Lansing	65,929	25.9	90,952	27.4	110,278	28.1	37.9	21.2
Northeast Fringe	23,450	9.2	28,234	8.5	31,451	8.0	20.4	11.4
Jackson	30,192	11.9	38,265	11.5	45,798	11.7	26.7	19.7
Area	254,364	100.0	332,357	100.0	392,009	100.0	30.7	17.9
Michigan	1,821,403		2,391,927		2,726,864		31.3	14.0
United States	45,070,315		56,435,273		64,639,247		25.2	14.5

Note: Detail may not add to totals due to rounding.

(a) Includes those employed persons not reporting industry and not reporting occupation in the census survey. Employed persons not reporting occupation are excluded from Tables 17 through 20; employed persons not reporting industry are excluded from Tables 21 through 26.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

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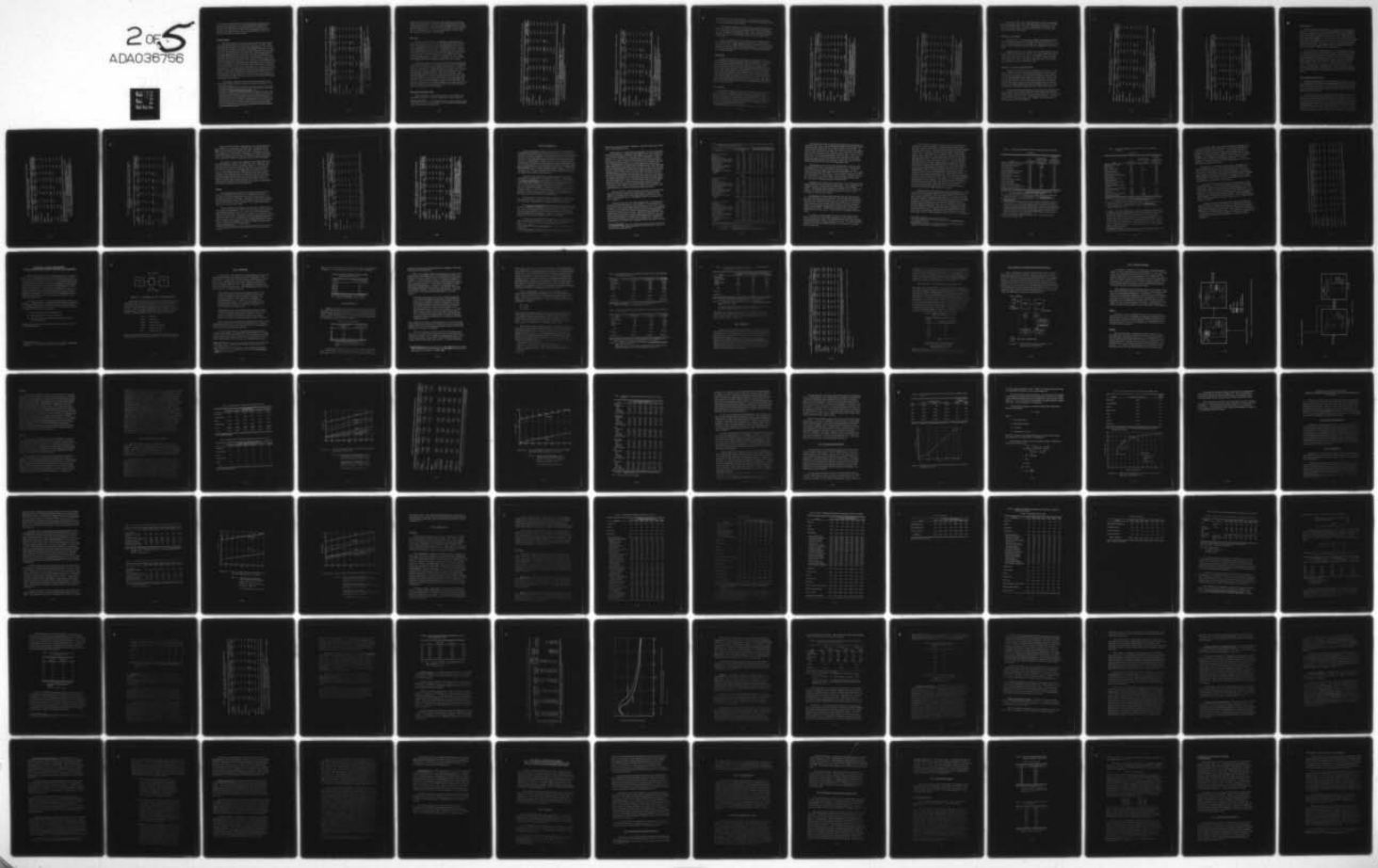

trend was reversed between 1950 and 1960 when employment in the Jackson subarea rose somewhat faster than employment in the Area and much faster than employment in the State and Nation.* In 1940-1950 and 1950-1960, employment in the West Central Belt and Northeast Fringe expanded slowly relative to the Area, the State, and the Nation.

Manufacturing

Data pertaining to the distribution of manufacturing employment among the subareas are given in Table 28. In 1960, nearly 62,600 people or 46.5 per cent of total employment in Area manufacturing was accounted for by the Grand Rapids subarea.** However, the predominance of this subarea declined a bit between 1940 and 1950, and also between 1950 and 1960. The Lansing subarea, with approximately 29,500 residents employed in manufacturing, accounted for the second largest share of this industry's 1960 employment in the Area, but the relative position of this subarea also declined between 1940 and 1960. It is especially noteworthy that between 1950 and 1960, manufacturing employment in the Lansing subarea rose by only 3.9 per cent while it was increasing by 14.6 per cent in the Area, 5.6 per cent in Michigan, and 19.3 per cent in the United States. A similar pattern existed in the Jackson subarea between 1940 and 1950, but between 1950 and 1960 manufacturing employment grew more rapidly in this subarea than in the Area, so that the share accounted for by residents of the Jackson subarea increased from 11.6 per cent to 12.1 per cent of total manufacturing employment in the Area.

The number of people living in the West Central Belt and Northeast Fringe subareas employed in manufacturing grew very

*The increase in employment in the Jackson subarea was entirely outside the city of Jackson as employment opportunities shifted to the area surrounding the city. See Michigan State Highway Department, Jackson, Michigan State Highway Plan, 1962, p 1.

**Comparison of available data on manufacturing employment suggest that data based on place of residence do *not* significantly distort the patterns of actual employment. In 1960, 63,432 people were employed by manufacturing firms located in the Grand Rapids subarea; 62,593 people living in the subarea were employed by manufacturing firms (wherever located). In the Lansing subarea, 30,261 were employed by manufacturing concerns, and 29,544 of those residing in the subarea were so employed. In the Jackson subarea, 17,820 were employed in manufacturing, and 16,256 of the subarea's residents worked in manufacturing industries. See also, Michigan Employment Security Division, Commuting Survey of the Lansing Metropolitan Area and Adjacent Counties, October 1958.

TABLE 28. EMPLOYMENT IN MANUFACTURING IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	38,415	50.1	56,064	47.7	62,593	46.5	45.9	11.6
West Central Belt	5,692	7.4	10,720	9.1	14,650	10.9	88.3	36.7
Lansing	18,825	24.5	28,444	24.2	29,544	21.9	51.1	3.9
Northeast Fringe	4,382	5.7	8,635	7.4	11,627	8.6	97.0	34.6
Jackson	9,437	12.3	13,605	11.6	16,256	12.1	44.2	19.5
Area	76,761	100.0	117,468	100.0	134,670	100.0	53.0	14.6
Michigan	703,834		981,289		1,035,892		39.4	5.6
United States	10,670,087		14,685,482		17,513,086		37.6	19.3

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

rapidly between 1940 and 1950 but from relatively small bases. There was an increase of 88.3 per cent in this group in the West Central Belt and of 97.0 per cent in the Northeast Fringe subarea between 1940 and 1950. Between 1950 and 1960, this growth continued, although the rate of increase was much less rapid than that experienced between 1940 and 1950.

Services*

In each of the subareas, employment in manufacturing grew more rapidly between 1940 and 1950 than between 1950 and 1960. In contrast to this pattern, employment in services in each of the subareas grew much more rapidly between 1950 and 1960 than between 1940 and 1950. Taking the Area as a whole, the data set forth in Table 29 indicate that there was an increase of 28.9 per cent in employment in services between 1940 and 1950 and of 49.8 per cent between 1950 and 1960. The rate of growth of employment in services was greater in the Area than in Michigan or the United States in each of the two decades.

There were relative declines in manufacturing employment in only the Grand Rapids and Lansing subareas between 1940 and 1960 and the Jackson subarea between 1940 and 1950. However, between 1940 and 1950, and again between 1950 and 1960, the only subarea experiencing a relative increase in employment in services was the Lansing subarea. This relative growth of the Lansing subarea is reflected by the fact that, between 1940 and 1950, employment in services increased by 50.6 per cent in the subarea, while it was growing by 26.6 per cent in Michigan and 17.7 per cent in the United States. Between 1950 and 1960, employment in services in the Lansing subarea increased by 61.5 per cent as compared with an increase of 44.9 per cent in Michigan and 34.2 per cent in the United States.

Wholesale and Retail Trade

Data pertaining to wholesale and retail trade employment are given in Table 30. In 1960, about 85 per cent of those so

*Services include education at all levels (both public and private), business and repair, personal, entertainment and recreation, hospitals, welfare, religious and nonprofit membership organizations, and other professional and related services.

TABLE 29. EMPLOYMENT IN SERVICES IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	18,480	43.6	22,427	41.0	32,820	40.1	21.4	46.3
West Central Belt	4,003	9.5	4,801	8.8	6,268	7.7	19.0	30.6
Lansing	11,675	27.6	17,584	32.2	28,403	34.7	50.6	61.5
Northeast Fringe	3,317	7.8	3,858	7.1	5,805	7.1	16.3	50.5
Jackson	4,871	11.5	5,956	10.9	8,510	10.4	22.3	42.9
Area	42,346	100.0	54,626	100.0	81,806	100.0	28.9	49.8
Michigan	296,071		374,694		542,827		26.6	44.9
United States	8,574,153		10,092,646		13,549,947		17.7	34.2

Note: Detail may not add to totals due to rounding.

Sources: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 30. EMPLOYMENT IN WHOLESALE AND RETAIL TRADE IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	19,572	45.9	28,182	45.7	32,727	45.6	44.0	16.1
West Central Belt	3,327	7.8	4,899	7.9	5,790	8.1	47.2	18.2
Lansing	11,093	26.0	16,552	26.8	19,616	27.4	49.2	18.5
Northeast Fringe	3,435	8.0	4,826	7.8	5,210	7.3	40.5	8.0
Jackson	5,234	12.3	7,287	11.8	8,324	11.6	39.2	14.2
Area	42,661	100.0	61,746	100.0	71,667	100.0	44.7	16.1
Michigan	292,318		418,269		484,018		43.1	15.7
United States	7,497,793		10,507,331		11,792,635		40.1	12.2

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

employed lived in the Grand Rapids, Lansing, and Jackson subareas; 45.6 per cent of the total was accounted for by people living in the Grand Rapids subarea alone.

The pattern of growth in employment in wholesale and retail trade in the total Area has closely paralleled that for Michigan, but Area growth has been significantly ahead of that for the United States. Growth for the subareas, Area, State, and Nation was almost three times as fast between 1940 and 1950 as in the 1950-1960 decade.

There was little shift in the concentration of employment in wholesale and retail trade among the subareas over the period from 1940 to 1960. Slight relative declines took place in the Grand Rapids, Northeast Fringe, and Jackson subareas. These declines were offset by slight relative increases in the West Central Belt and Lansing subareas.

Agriculture

As indicated previously, agricultural employment has been most important, relative to total subarea employment, in the West Central Belt and Northeast Fringe subareas. However, as the data set forth in Table 31 indicate, employment in agriculture in the Area has been concentrated in the Lansing, Grand Rapids, and West Central Belt subareas, which together accounted for about 75 per cent of total agricultural employment in the Area in 1940, 1950, and 1960. Between 1940 and 1950 agricultural employment in the United States declined by 17.8 per cent. In Michigan the decline was 25.4 per cent and in the Area 26.2 per cent. The more rapid percentage decline of 38.2 per cent experienced in the United States between 1950 and 1960 was closely paralleled in both Michigan and in the Area.*

Construction

As the data in Table 32 indicate, the greatest concentration of employment in construction in the Area is accounted for by people living in the Grand Rapids and Lansing subareas, which together accounted for 71.6 per cent of the Area's construction employment in 1940, for 74.3 per cent by 1950, and for 75.5 per cent in 1960. Since 1940, relative declines have been experienced in each of the remaining three subareas.

* The changes of Census definitions discussed on page I-60 influence the size of this decline.

TABLE 31. EMPLOYMENT IN AGRICULTURE, FORESTRY, AND FISHERIES IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	10,619	23.5	8,016	24.0	5,199	25.6	-24.5	-35.1
West Central Belt	11,372	25.2	8,286	24.9	4,716	23.2	-27.1	-43.1
Lansing	11,399	25.2	8,580	25.7	5,653	27.8	-24.7	-34.1
Northeast Fringe	8,291	18.3	5,969	17.9	3,061	15.0	-28.0	-48.7
Jackson	3,509	7.8	2,505	7.5	1,699	8.4	-28.6	-32.2
Area	45,190	100.0	33,356	100.0	20,328	100.0	-26.2	-39.0
Michigan	216,694		161,615		93,662		-25.4	-42.0
United States	8,559,134		7,033,591		4,349,884		-17.8	-38.2

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 32. EMPLOYMENT IN CONSTRUCTION IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	4,565	44.1	7,528	45.0	8,813	43.1	64.9	17.1
West Central Belt	1,090	10.5	1,517	9.1	1,737	8.5	39.2	14.5
Lansing	2,846	27.5	4,894	29.3	6,609	32.4	72.0	35.0
Northeast Fringe	800	7.7	1,132	6.8	1,343	6.6	41.5	18.6
Jackson	1,052	10.2	1,634	9.8	1,924	9.4	55.3	17.7
Area	10,353	100.0	16,705	100.0	20,426	100.0	61.4	22.3
Michigan	73,909		118,339		125,562		60.1	6.1
United States	2,087,564		3,457,980		3,815,937		65.6	10.4

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

During the 1940-1950 decade the Area's construction employment increased a little faster than Michigan's but was slower than that of the United States; however, during the 1950's the Area's percentage growth was almost four times that for Michigan and over twice that for the Nation.

Public Administration

Nearly half of all employment in public administration in the Area has been accounted for by people living in the Lansing subarea, as shown by data given in Table 33. The share accounted for by each of the remaining subareas has not changed markedly since 1940.

Between 1940 and 1950, employment in public administration in the United States increased by 77.7 per cent, compared with the much lower rate of 50.7 per cent for Michigan and the moderate rate of 24.9 per cent for the Area. In contrast, during the 1950-1960 decade, the rates of growth in the Area, State, and Nation were about the same at about 28 per cent.

Finance, Insurance, and Real Estate

Slightly less than half of total employment in finance, insurance, and real estate in the Area has historically been accounted for by people living in the Grand Rapids subarea. This subarea and the Lansing subarea accounted for approximately 80 per cent of total employment in these industries in the Area. As the data set forth in Table 34 reveal, the share accounted for by people living in the Jackson subarea declined slightly between 1940 and 1960, while slight relative growths were shown over the 20-year period by the Northeast Fringe and West Central Belt subareas.

Employment in these industries in the Nation, Michigan, and the Area grew more rapidly between 1950 and 1960 than between 1940 and 1950 and at a rate somewhat greater than that in the United States between 1940 and 1950. In each of these decades, employment in these industries grew more rapidly in the Area than in Michigan or in the United States.

TABLE 33. EMPLOYMENT IN PUBLIC ADMINISTRATION IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	2,649	27.9	3,192	26.9	4,158	27.3	20.5	30.3
West Central Belt	708	7.5	1,017	8.6	1,123	7.4	43.6	10.4
Lansing	4,498	47.4	5,373	45.3	7,238	47.6	19.4	34.7
Northeast Fringe	491	5.2	638	5.4	855	5.6	29.9	34.0
Jackson	1,143	12.0	1,633	13.8	1,846	12.1	42.9	13.0
Area	9,489	100.0	11,853	100.0	15,220	100.0	24.9	28.4
Michigan	48,911		73,708		93,837		50.7	28.7
United States	1,415,283		2,514,469		3,202,890		77.7	27.4

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 34. EMPLOYMENT IN FINANCE, INSURANCE, AND REAL ESTATE IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	3,130	47.7	4,364	47.4	6,324	47.1	39.4	44.9
West Central Belt	353	5.4	513	5.6	766	5.7	45.3	49.3
Lansing	1,996	30.5	3,039	33.0	4,339	32.3	52.2	42.8
Northeast Fringe	310	4.7	445	4.8	707	5.3	43.5	58.9
Jackson	765	11.7	850	9.2	1,282	9.6	11.1	50.8
Area	6,554	100.0	9,211	100.0	13,418	100.0	40.5	45.7
Michigan	48,198		64,417		89,556		33.6	39.0
United States	1,474,681		1,919,610		2,694,630		30.2	40.4

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

Transportation

Data pertaining to employment in transportation are given in Table 35. Over 50 per cent of the total employment in transportation was accounted for by residents of the Grand Rapids subarea. This represented a continual increase from 1940, when the Grand Rapids subarea accounted for 45.8 per cent of the Area's total employment in this industry. The share accounted for by people living in the West Central Belt and in the Lansing subareas also rose between 1940 and 1960. The relative increase experienced by these subareas was offset by the relative declines which took place in both the Northeast Fringe and Jackson subareas.

The low rate of growth experienced in the Northeast Fringe and Jackson subareas in employment in this industry between 1940 and 1950 served to keep the rate of expansion for the Area below that for Michigan and the United States. Between 1950 and 1960, absolute declines in employment in transportation experienced in these two subareas, combined with virtual stability in the West Central Belt, resulted in a decline from 12,617 to 12,205 in the Area. This decline of 3.3 per cent is reasonably similar to declines of 2.6 per cent in Michigan and 7.2 per cent in the Nation over the same decade. Decreases in railroad employment during this decade more than offset gains in trucking all over the United States.

Communications and Utilities

Although employment in communications, utilities, and sanitary services was earlier shown to be disproportionately high compared with total employment in the Jackson subarea, this subarea did not account for as great a proportion of the employment in the Area as did the Grand Rapids subarea in 1940, 1950 or 1960, as shown by data in Table 36.

Over the 20-year period from 1940 to 1960, the share of employment in these industries accounted for by people living in the Grand Rapids subarea declined from 39.1 per cent to 36.2 per cent. There was also a slight decline in the share of the subarea total accounted for by people living in the West Central Belt and Northeast Fringe subareas. The share of the Area's total accounted for by residents of the Lansing subarea increased from 21.8 to 24.9 per cent between 1940 and 1960, while the share accounted for by people living in the Jackson subarea stayed about constant at 24 per cent.

TABLE 35. EMPLOYMENT IN TRANSPORTATION IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	4,620	45.8	6,012	47.7	6,141	50.3	30.1	2.1
West Central Belt	506	5.0	669	5.3	670	5.5	32.2	0.1
Lansing	1,437	14.3	2,222	17.6	2,308	18.9	54.6	3.9
Northeast Fringe	1,344	13.3	1,466	11.6	1,368	11.2	9.1	-6.7
Jackson	2,175	21.6	2,248	17.8	1,718	14.1	3.4	-23.6
Area	10,082	100.0	12,617	100.0	12,205	100.0	25.1	-3.3
Michigan	63,256		88,981		86,678		40.7	-2.6
United States	2,193,775		2,953,979		2,739,913		34.6	-7.2

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

TABLE 36. EMPLOYMENT IN COMMUNICATIONS, UTILITIES, AND SANITARY SERVICES IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	2,362	39.1	3,365	38.6	3,812	36.2	42.5	13.3
West Central Belt	408	6.8	668	7.7	678	6.4	63.7	1.5
Lansing	1,313	21.8	2,018	23.2	2,626	24.9	53.7	30.1
Northeast Fringe	513	8.5	738	8.5	863	8.2	43.8	16.9
Jackson	1,438	23.8	1,920	22.0	2,558	24.3	33.5	33.2
Area	6,034	100.0	8,709	100.0	10,537	100.0	44.3	21.0
Michigan	37,446		63,582		68,910		69.8	8.4
United States	949,452		1,495,882		1,718,234		57.6	14.9

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

Between 1940 and 1950, employment in the United States by these industries increased by 57.6 per cent, compared with the higher rate of growth in Michigan (69.8 per cent) and the lower rate of growth in the Area (44.3 per cent). This pattern was reversed between 1950 and 1960, as employment in these industries in the United States grew by only 14.9 per cent while it increased by 21.0 per cent in the Area and only 8.4 per cent in Michigan.

The electric energy requirements (for meeting loads in all systems) and peak loads for the subareas, Area, Michigan, and the United States are shown by data in Table 37. With total requirements of 4.15 billion kwhr in 1960, the Area represented 14.3 per cent of those for Michigan and 0.55 of those for the nation. Percentage increase in the decades 1940-1950 (115 per cent) and 1950-1960 (108 per cent) was less than that for both Michigan and the United States in 1940-1950, but was more than that for Michigan (89 per cent) and still less than that for the Nation (123 per cent) during the period 1950-1960. Energy requirements throughout the two decades were heavily concentrated in the Grand Rapids and Lansing subareas.

Mining

The mining industry has been relatively insignificant as a source of employment in the Area, accounting for less than 0.5 per cent of total employment over the 20-year period. As data given in Table 38 indicate, the greatest concentration was in the Grand Rapids subarea which accounted for 46.3 per cent of the Area's total in 1960. This, however, was a substantial decline from the 70.2 per cent in 1940.

Between 1940 and 1950 there was a decline of 50 per cent in Area mining employment*, compared with a decline of 2.8 per cent in Michigan and an increase of 1.3 per cent in the United States. Between 1950 and 1960, there was a 30.9 per cent increase in employment in the Area, accounted for mainly by petroleum production from new discoveries in Jackson County and expanded sand and gravel output in the Lansing subarea. During that decade, employment in mining in Michigan was virtually stable but declined by nearly 30 per cent in the United States.

*The drop was in the Grand Rapids area, entirely in petroleum (Walker Field). This decline was caused by depletion of the field. The field was discovered in 1938 and attained peak output in 1940.

TABLE 37. ELECTRIC-UTILITY ENERGY REQUIREMENTS AND PEAK LOADS IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	Energy Requirements, million kwhr			Peak Loads, thousand kw			Per Cent Increase			
							Energy Requirements		Peak Loads	
	1940	1950	1960	1940	1950	1960	1940-1950	1950-1960	1940-1950	1950-1960
Grand Rapids	425	910	1,908	85	180	345	114.1	109.7	111.8	91.7
West Central Belt	45	115	255	15	18	58	155.6	121.7	20.0	222.2
Lansing	290	610	1,235	60	117	220	110.3	102.5	95.0	88.0
Northeast Fringe	40	95	207	12	15	47	137.5	117.9	25.0	213.3
Jackson	130	270	545	28	55	100	107.7	101.9	96.4	81.8
Area	930	2,000	4,150	200	385	770	115.1	107.5	92.5	100.0
Michigan	7,000	15,316	29,000	1,725	2,950	5,520	118.8	89.3	71.0	87.1
United States	144,985	341,073	761,380	N.A.	64,135	137,976	135.2	123.2	N.A.	115.1

Source: Compiled by the Federal Power Commission, Regional Office, Chicago, Illinois, 1964.

TABLE 38. EMPLOYMENT IN MINING IN THE SUBAREAS, AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Subarea	1940	Per Cent of Area	1950	Per Cent of Area	1960	Per Cent of Area	Percentage Increase 1940-1950	Percentage Increase 1950-1960
Grand Rapids	807	70.2	299	52.2	347	46.3	-62.9	16.1
West Central Belt	96	8.4	96	16.7	60	8.0	0.0	-37.5
Lansing	62	5.4	60	10.5	126	16.8	-3.2	110.0
Northeast Fringe	171	14.9	91	15.9	75	10.0	-46.8	-17.6
Jackson	13	1.1	27	4.7	142	18.9	107.7	425.9
Area	1,149	100.0	573	100.0	750	100.0	-50.1	30.9
Michigan	15,846		15,409		14,340		-2.8	-0.4
United States	918,853		930,968		654,006		1.3	-29.7

Note: Detail may not add to totals due to rounding.

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

I-14. Key Industries

In the early stages of this research, efforts were undertaken to identify those industries in the Area which were most likely to influence its future economic history and which were most important in terms of water consumption. Unfortunately, there is no single source of fully comprehensive and accurate data on employment in the Area. Consequently, Battelle's analysis is based principally on data from the Census, but the reported Census employment data were checked against more recent data available from County Business Patterns* and also data supplied by the Michigan Employment Security Commission. Data from the Census of Manufactures are too sparse (as a result of disclosure problems) to permit meaningful employment estimates for the Area.

The most important manufacturing industry in the Area is transportation equipment**, as shown in Table 39. According to the Census of Population, this industry accounted for 28.7 per cent of manufacturing employment of those people living in the Area in 1960. The other key major manufacturing industries in the Area are fabricated metal products, machinery except electrical machinery, electrical machinery, furniture and fixtures, and food and kindred products. Each, with the exception of food and kindred products, accounted for a greater proportion of manufacturing employment in the Area than in the United States.

Census data for 1960 point up the importance of these manufacturing industries to the Area. The six together accounted for 75.0 per cent of employment as reported by the 1960 Census.

The Census of Population (Table 39) provides the only data for analysis of historical evolution of the key industries within the Area. As a result of changing definitions, these data are available on a strictly comparable basis since 1940 for only three of the six key major manufacturing industries. However, comparable data are available for each of the industries for 1950 and 1960.

In 1950, the six major industrial groups accounted for 79 per cent of employment in the Area. By 1960, this percentage had fallen to 75. Between 1950 and 1960 employment increased

*U. S. Bureau of the Census, County Business Patterns, First Quarter, 1962, Part 4A, East North Central States.

** "Transportation equipment" is used here to include "motor vehicles and motor vehicle equipment" and "transportation equipment except motor vehicles", which are shown in Table 39.

absolutely in three of the key industries, remained generally stable in two, and declined in one.

Employment in transportation equipment, the most important industry in the Area, increased only slightly from 38.6 thousand to 38.7 thousand between 1950 and 1960 while total manufacturing employment increased from 117 thousand to 135 thousand. Consequently, the share of manufacturing employment accounted for by this industry declined from 32.9 to 28.7 per cent between 1950 and 1960. Employment in nonelectrical machinery was practically stable between 1950 and 1960 with the result that its share of manufacturing employment declined from 15.6 to 13.9 per cent over the decade. Employment in furniture and related products declined by approximately 1,600 between 1950 and 1960, causing its share of manufacturing employment to decline from 10.9 to 8.3 per cent.* Increases in employment, both absolute and relative to total manufacturing employment, were experienced between 1950 and 1960 in the fabricated metals, electrical machinery, and food and kindred products industries. Of those people living in the Area, nearly 5,000 more were employed in the fabricated-metals industry in 1960 than in 1950, about 2,200 more in electrical machinery, and approximately 2,200 more in food and kindred products.

The significance of these trends in key major manufacturing industries is more clearly seen when they are compared with changes in Michigan and in the United States between 1950 and 1960. The pertinent data for Michigan and the United States also are in Table 39.

Between 1950 and 1960, when employment in transportation equipment in the Area was virtually stable, it increased by over 35 per cent in the United States and declined by over 17 per cent in Michigan. The major industry group is made up of two components, motor vehicles and motor vehicle equipment and transportation equipment except motor vehicles. In both Michigan and the Area, motor vehicles and motor vehicle equipment account for the overwhelming proportion of employment in transportation equipment, but in the United States in 1960, more people were employed in manufacture of transportation equipment other than motor vehicles.

* This Census of Population industry group includes lumber and wood products in addition to furniture and fixtures. In 1962, lumber and wood products accounted for less than 1.0 per cent of the Area's manufacturing employment.

TABLE 39. DISTRIBUTION AND GROWTH OF MANUFACTURING EMPLOYMENT BY MAJOR INDUSTRY GROUP IN THE AREA, MICHIGAN, AND THE UNITED STATES, 1940, 1950, AND 1960

Industry Group	Employed Persons			Percentage Distribution			Percentage Increase	
	1940	1950	1960	1940	1950	1960	1940-1950	1950-1960
Area								
Furniture, lumber and wood products	11,751	12,801	11,198	15.3	10.9	8.3	8.9	-12.5
Primary metal	9,424	4,503	6,245	12.3	3.8	4.6	66.8	38.7
Fabricated metal		11,219	16,144		9.5	12.0		43.9
Machinery, except electrical	10,077	18,361	18,695	13.1	15.6	13.9	133.8	1.8
Electrical machinery, equipment, and supplies		5,205	7,424		4.4	5.5		42.6
Motor vehicles and motor vehicle equipment	21,778	36,739	36,037	28.4	31.3	26.8	68.7	-1.9
Transportation equipment, except motor vehicle	752	1,858	2,624	1.0	1.6	1.9	147.1	41.2
Food and kindred products	5,453	6,652	8,868	7.1	5.7	6.6	22.0	33.3
Textile mill products	1,883	1,359	688	2.5	1.2	0.5	-27.8	-49.4
Apparel and other fabricated textile products	1,172	1,394	2,022	1.5	1.2	1.5	18.9	45.0
Printing, publishing, and allied products	3,365	4,817	6,379	4.4	4.1	4.7	43.2	32.4
Chemical and allied products	895	1,565	2,404	1.2	1.3	1.8	74.9	53.6
Other durable goods	10,201	4,463	9,408	13.3	3.8	7.0	7.8	110.8
Other nondurable goods (including industry not specified)		6,532	6,536		5.6	4.9		0.1
Total	76,751	117,468	134,670	100.0	100.0	100.0	53.0	14.6
Michigan								
Furniture, lumber and wood products	34,197	40,069	34,428	4.9	4.1	3.3	17.2	-14.1
Primary metal	79,160	62,547	71,670	11.2	6.4	6.9	51.9	14.6
Fabricated metal		57,668	91,780		5.9	8.9		59.2
Machinery, except electrical	41,871	109,492	147,059	5.9	11.2	14.2	161.5	34.3
Electrical machinery, equipment, and supplies	17,889	20,969	31,695	2.5	2.1	3.1	17.2	51.2
Motor vehicles and motor vehicle equipment	357,055	468,135	377,163	50.7	47.7	36.4	31.1	-19.4
Transportation equipment, except motor vehicle	5,934	11,354	19,281	0.8	1.2	1.9	91.3	69.8
Food and kindred products	42,535	51,617	62,382	6.0	5.3	6.0	21.4	20.9
Textile mill products	6,286	4,720	3,553	0.9	0.5	0.3	-24.9	-24.7
Apparel and other fabricated textile products	7,292	7,776	8,582	1.0	0.8	0.8	6.6	10.4
Printing, publishing, and allied products	22,972	31,142	45,742	3.3	3.2	4.4	35.6	46.9
Chemical and allied products	18,779	29,566	40,909	2.7	3.0	3.9	57.4	38.4
Other durable goods	69,864	30,825	45,302	9.9	3.1	4.4	23.4	47.0
Other nondurable goods (including industry not specified)		55,409	56,346		5.6	5.4		1.7
Total	703,834	981,289	1,035,892	100.0	100.0	100.0	39.4	5.6
The United States								
Furniture, lumber and wood products	903,496	1,196,116	1,067,252	8.5	8.1	6.1	32.4	-10.8
Primary metal	1,507,107	1,184,975	1,224,922	14.1	8.1	7.0	34.8	3.4
Fabricated metal		847,209	1,291,709		5.8	7.4		52.5
Machinery, except electrical	691,180	1,253,533	1,568,035	6.5	8.5	8.9	81.4	25.1
Electrical machinery, equipment, and supplies	420,925	861,307	1,487,412	3.9	5.9	8.6	104.6	72.7
Motor vehicles and motor vehicle equipment	569,767	856,786	841,861	5.3	5.8	4.8	50.4	-1.7
Transportation equipment, except motor vehicle	307,869	486,371	976,837	2.9	3.3	5.6	58.0	100.8
Food and kindred products	1,202,782	1,481,280	1,822,477	11.3	10.1	10.4	23.2	23.0
Textile mill products	1,166,470	1,227,525	954,036	10.9	8.3	5.4	5.2	-22.3
Apparel and other fabricated textile products	783,735	1,066,511	1,159,163	7.3	7.3	6.6	36.1	8.7
Printing, publishing, and allied products	637,957	862,936	1,141,192	6.0	5.9	6.5	35.3	32.2
Chemical and allied products	400,852	637,349	864,542	3.8	4.3	4.9	59.0	35.6
Other durable goods	2,077,947	1,078,181	1,370,661	19.5	7.3	7.8	31.1	27.1
Other nondurable goods (including industry not specified)		1,645,403	1,742,987		11.2	9.9		5.9
Total	10,670,087	14,685,482	17,513,086	100.0	100.0	100.0	37.6	19.3

Note: Detail may not add to totals due to rounding.

Sources: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Table 18.
U. S. Census of Population: 1950, General Characteristics, Michigan, Table 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 62 and 85.
U. S. Census of Population: 1960, General Social and Economic Characteristics, United States Summary, Table 92.

Employment in motor vehicles and equipment manufacture declined by over 19 per cent in Michigan between 1950 and 1960 but by less than 2 per cent in the Area and also in the United States. In transportation equipment, except motor vehicles, employment grew by 41.2 per cent in the Area, 69.8 per cent in Michigan and 100.8 per cent in the United States between 1950 and 1960. Hence, in that portion of transportation equipment most important in the Area, motor vehicles, the decline between 1950 and 1960 closely paralleled that experienced in the nation as a whole and was much less severe than that for the state of Michigan generally.

Employment in the Area in fabricated-metal manufacturing increased by 43.9 per cent between 1950 and 1960. This growth, representing an increase of nearly 5,000 employees, was at a lower rate than that experienced in the United States (52.5 per cent) or in Michigan (59.2 per cent). A similar pattern appears for electrical machinery. In this industry, employment increased by 42.6 per cent in the Area, by 72.7 per cent in the United States, and 51.2 per cent in Michigan between 1950 and 1960.

Employment in nonelectrical machinery in the Area grew very slightly between 1950 and 1960 (1.8 per cent). This stability was in marked contrast to the growth in both Michigan and the United States. Employment in this industry increased by over 25 per cent in the U. S. between 1950 and 1960 and by over 34 per cent in Michigan during the same period.

Employment in the furniture industry declined nationally by 10.8 per cent between 1950 and 1960. The decline experienced in the Area was somewhat greater (12.5 per cent) than the national decline but not so severe as the decline in Michigan (14.1 per cent). In the final key major manufacturing industry, food and kindred products, employment increased by over one-third in the Area between 1950 and 1960. This growth surpassed the growth of the United States (23.0 per cent) as well as that of Michigan (20.9 per cent).

In addition to these industries which are important to the future of the Area because they constitute a major portion of the Area's employment, there are industries which merit special attention because they are large consumers of water. The best available measure which permits identification of such industries is water use per employee.

Factors based on water use per employee have been estimated for those Area industries employing more than 1,000 persons in 1962* and for those industries that have been identified as heavy water users. The per-employee factor multiplied by 1962 industry employment provides an estimate of total water use per day. These data are set forth in Table 40 for the key water-using industries. Those industries considered but not selected as "key users" because water withdrawals are less than 900,000 gallons a day are listed in Table 41. In this analysis, the water-use factors have been developed primarily from the industrial water-use data published in the 1958 Census of Manufacturers**. These water-use factors are more meaningful at the 4-digit Standard Industrial Classification level since the aggregations at the 3, and particularly at the 2-digit levels, represent totals for industries which differ widely in processes, products, materials, employment, etc. Therefore, the Area industries were examined at the SIC 4-digit level whenever possible. Selected industry statistics at the 4-digit level were published for industrial-water-use regions. The Area is part of the Western Great Lakes Region and, whenever available, factors were derived from the regional rather than the national statistics. For those key industries not included in the Census data, factors were derived from the Ohio water-use study***.

Although useful in estimating the relative magnitudes of water used by the various Area industries when specific information for the Area is not available, the limitations of the water-use factors used in this analysis should be kept in mind. It cannot be assumed that Area industry conditions are exactly like those in a composite average of that industry's activity in other geographic areas. Furthermore, the Ohio survey of water use indicates that, even within a defined geographic area, there is considerable variation in water withdrawal among plants and factories engaged in essentially the same activity, as defined by the 4-digit classification: "For most 4-digit groups, the heaviest user of water has a withdrawal per day per 1,000 employees of the order of 3 or 4 times the

*According to Michigan Employment Security Commission data.

**U. S. Bureau of the Census, U. S. Census of Manufactures: 1958. Industrial Water Use, Subject Report MC 58 (1)-11.

***"Industrial Water Use in Ohio", Ohio Department of Natural Resources, Division of Water, Report No. 8, Ohio Water Plan Inventory (December, 1960).

TABLE 40. INDUSTRIES CONSIDERED AND SELECTED AS KEY WATER-USING INDUSTRIES

(1962 Data)

Industry	1962 Employment[a]	Water-Withdrawal Factor[b], 1000 gal/day/employee	Employment Times Withdrawal Factor, million gal/day
Industrial inorganic chemicals, nec	375	26.0[c]	9.750
Motor vehicles and equipment	29,304	0.3[c]	8.791
Petroleum refining	499	13.4[d]	6.687
Tires and inner tubes	1,555	2.1	3.266
Household refrigerators and freezers	3,956	0.8	3.165
Aluminum rolling and drawing	1,300	2.4	3.120
Aircraft and parts	1,621	1.8	2.918
Farm machinery and equipment	1,198	2.3[c]	2.755
Metal stampings	5,340	0.5	2.670
Cutlery, hand tools, and hardware	4,461	0.5	2.231
Iron and steel forgings	1,936	0.8	1.549
Commercial printing	1,796	0.6	1.078
Condensed and evaporated milk	180	5.4	0.972
Coating, engraving, and allied services	1,515	0.6[e]	0.909
Machinery, except electrical, nec	1,798	0.5	0.900

(a) Source: U. S. Bureau of the Census, County Business Patterns, First Quarter, 1962, Part 4A, East North Central States, Tables 1 and 2. Battelle estimates.

(b) Except where noted otherwise by Footnotes (c), (d), and (e), this factor is the United States average derived from U. S. Census of Manufacturers: 1958. Industrial Water Use.

(c) Western Great Lakes Region average derived from U. S. Census of Manufacturers: 1958. Industrial Water Use.

(d) This water-use factor for petroleum refining in the Western Great Lakes Region amounts to the very high figure of 40.6 thousand gallons per day per employee. However, this is heavily influenced by the huge refining centers in Whiting, Indiana, and nearby Chicago adjacent to to virtually unlimited water supplies from Lake Michigan. It is felt that the refining operations in Gratiot and Montcalm Counties within the Service Area would have water-use factors more nearly approximating those in the Ohio or Upper Mississippi Regions, where water is not so abundant. Therefore, a water-use factor of 13.4 thousand gallons per employee per day, as given in the Ohio water-use study, has been used.

(e) Ohio average derived from "Industrial Water Use in Ohio". Ohio Water Plan Inventory, Report No. 8 (December, 1960).

TABLE 41. INDUSTRIES CONSIDERED AND NOT SELECTED AS KEY WATER-USING INDUSTRIES

(1962 Data)

Industry	1962 Employment[a]	Water-Withdrawal Factor[b], 1000 gal/day/employee	Employment Times Withdrawal Factor, million gal/day
Household furniture, wood	4,350	0.2	0.870
Bakery products	2,860	0.3	0.858
Motors and generators	2,825	0.3	0.848
Fabricated textiles, nec	2,057	0.04[c]	0.823
Special dies and tools	2,547	0.3	0.764
Special industry machinery	1,056	0.7	0.739
Fabricated structural metal products	1,827	0.4	0.731
Gypsum products	327	2.2	0.719
Textile finishing, exc. wool	175	3.6	0.630
Nonferrous foundries	1,093	0.4	0.437
Screw machine products and bolts	1,019	0.4	0.408
Scientific instruments	3,900	0.1	0.390
Plumbing and nonelectric heating products	1,263	0.3	0.379
Commercial refrigeration machinery	1,233	0.3	0.370
Office furniture, metal	1,090	0.3[c]	0.327
Newspapers	1,332	0.2	0.266
Public building and related furniture	1,570	0.1[c]	0.157
Footwear, except rubber	1,170	0.04[c]	0.047

(a) Source: U. S. Bureau of the Census, County Business Patterns, First Quarter, 1962, Part 4A, East North Central States, Tables 1 and 2. Battelle estimates.

(b) Except where noted otherwise by Footnotes (c), (d), and (e), this factor is the United States average derived from U. S. Census of Manufacturers: 1958. Industrial Water Use.

(c) Ohio average derived from "Industrial Water Use in Ohio". Ohio Water Plan Inventory, Report No. 8 (December, 1960).

average. For the 2-digit groups, which are far less homogeneous in activity than the 4-digit groups, the water withdrawal per 1,000 employees ranges from 3 to 11 times, and in one case 1,000 times, that of the average of the group."* Also, it must be kept in mind that these factors pertain to conditions existing 6 and, in some instances, 10 years ago. Recent technical-economic trends have certainly affected water-withdrawal factors for some industries – upward or downward – but by how much for what industries is not readily available.

*"Development of Procedures for Forecasting Water Demand", Report by Battelle Memorial Institute for Division of Water, Ohio Department of Natural Resources, pp 20-21 (July 31, 1959).

It is worthy of note, also, that most of the operations in two of the heavier water-using industries – "petroleum refining" and "industrial inorganic chemicals nec" – are located outside the boundaries of the Grand River watershed but inside the Area as defined. A sizable petroleum refinery is located in Alma, and an inorganic chemicals plant in nearby St. Louis – both in northern Gratiot County outside the Grand River watershed. A small petroleum refinery is located within the watershed in Carson City (southeastern Montcalm County).

Subsequent to consultation with the Corps of Engineers, it was determined that six of these large water-using industries, motor vehicles and equipment, tires and innertubes, household refrigerators and freezers (household appliances), metal stampings, cutlery, hand tools and hardware, and iron and steel forgings (miscellaneous primary metals) would be singled out for special consideration. As a result, specific employment forecasts have been made for these industries by subarea.

In addition to employment forecasts, projections of value added by manufacture for each of these industries have also been undertaken. These projections have been estimated on the basis of the value added as reported in state and/or national data. This approach is necessary since the Census of Manufacturers does not provide comprehensive data on value added for small geographic areas where "disclosure" problems appear. The limited historical data which are available for each of these six "key" industries are shown in Table 42.

The data in Table 42 represent estimated value added per employee in each of these industries on a constant-dollar basis. Data on annual value added per employee have been deflated by the appropriate wholesale price index for each industry to estimate these data in constant-dollar terms. The purpose of such estimates is to eliminate, to the extent possible, the effect of relative price changes on the trends in value added per employee in these industries.

TABLE 42. UNITED STATES VALUE ADDED PER EMPLOYEE, KEY INDUSTRIES, 1954-1963

Industry	SIC	Value Added per Employee, 1957-1959 dollars									
		1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Tires and tubes	301	10,791	11,411	10,872	11,392	12,890	14,416	14,861	15,824	17,000	17,196
Miscellaneous primary metals	339	9,885	11,400	11,041	10,215	8,543	9,718	9,397	9,571	11,167	10,765
Cutlery, hand tools, and hardware	342	8,373	9,327	9,097	8,565	8,840	10,074	10,017	9,962	10,666	11,687
Metal stampings	346	7,815	8,144	7,898	7,620	8,340	9,150	9,047	9,153	9,506	9,699
Household appliances	363	8,404	9,390	9,728	9,824	10,857	11,459	11,368	12,231	13,993	15,416
Motor vehicles	371	10,418	13,376	11,711	12,051	11,661	14,143	14,425	14,701	17,264	18,202
All durables	--	8,694	9,343	9,144	9,020	9,162	9,902	9,850	10,102	10,873	11,432

Sources: (1954-1958) Census of Manufactures, 1954 and 1958; (1959-1962) Survey of Manufacturers, 1962.

SECTION D. GRAND RIVER BASIN: POPULATION PROJECTIONS IN THE AREA AND SUBAREAS

Population projections on a regional basis are a crucial element in developing projections of over-all economic structure, since population is a determinant of and is determined by the level of economic activity within a region. In recognition of these dual characteristics of population projections, Battelle's methodology involves a complex set of interactions between population projections and projections of the structure of employment. To simplify the presentation of methodology and results, this report outlines four basic stages of analysis undertaken in developing the population projections. At the same time, intermediate data are omitted, since the purpose of this report is to provide a statement of final results.

The basic elements of population projections are shown in Figure 4. The population at the beginning of the projection period, t_o in Figure 4 and in this case 1960, is given.* The population at any subsequent time (t_i, in Figure 4) is derived from the initial population in terms of three variables:

(1) Births during the intervening period

(2) Deaths during the intervening period

(3) Net migration during the period of persons into or out of the region.

Each of these three variables will be considered in turn in the following paragraphs.

*Population projections are developed on the basis of population as reported in 1960 Census of Population, Vol 1, Characteristics of the Population, Part 24, Michigan.

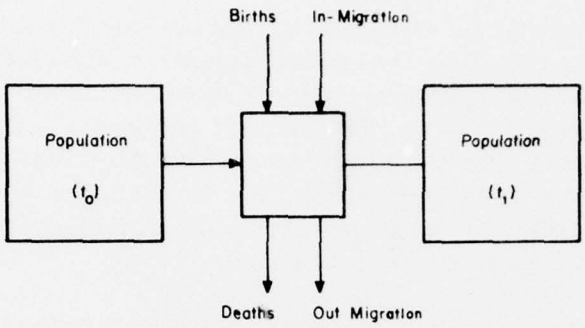

FIGURE 4. DYNAMICS OF POPULATION CHANGE

The interval between t_0 and t_1 may be selected to equal any convenient number of years or months. In the calculations developed for this study an interval of 2 years was used in order to take into account the flow of population from one age group to another. This is especially important since fertility, mortality, and migration rates differ significantly among the various age groups. In this analysis, six age classes have been used:

0-13	Children
14-19	Teenagers
20-24	Young adults
25-44	Prime-age adults
45-64	Middle-age adults
65+	Retired adults.

These classes were selected to establish relatively homogeneous groups for each of the variables discussed on the following page.

I-15. Death Rate

It is generally recognized that rising standards of living, improved medical care, and upgraded scientific knowledge have lowered the "crude death rate" (the number of deaths per year per one thousand residents) during the past 160 years. Donald J. Bogue* estimates that the crude death rate declined by 60 to 65 per cent between 1800 and 1957. This impressive reduction of crude death rates can hardly be continued during the course of the next 55 years. As Bogue points out:

> "The extent to which longevity actually increases in the future will depend not only on progress in the fields of medicine and public heath, but also on the health conservation activities of the population. Longevity, or even good health itself, is only one of several items valued by human beings. Often they are willing to risk earlier death in order to live heartily, sedentarily, or at a certain socioeconomic level.
>
> "Although the future may bring impressive proportional reductions in death rate, the point declines will be rather small in comparison with those of the past. It is not possible to repeat the impressive feat of reducing the death rate from 28 to 30 per thousand to 10 per thousand."

This view was also presented by Woodhall and Jablon,** who employed data for 1949-1951 which indicated that the complete elimination of all infective and parasitic diseases would add only about 1 year of life expectation at birth.

In view of this evidence, the population projections presented in this analysis are based upon the assumption of a modest improvement in the crude death rates. Data used in the calculations presented are based on actual values reported for 1960, related to the historic trend in terms of a gradual improvement.

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*Bogue provides a useful summary discussion of trends in the birth rate in The Population Of the United States, Chapter 9, "Mortality and Causes of Death", The Free Press of Glencoe Illinois (1959), pp 168-211.

**Barnes Woodhall and Seymour Jablon "Prospects For Future Increasing Average Longevity Geriatrics Vol. 12, No. 12, pp 586-591 (October, 1957), as quoted in Current Population Reports, Series P-25, No. 286, p 25.

Data for estimated and projected annual average crude death rates as used in U. S. Census, Series B, are reported in Table 43.

TABLE 43. ESTIMATED AND PROJECTED ANNUAL AVERAGE CRUDE DEATH RATES, 1950-1980

Period[a]	Rate Per 1000 Population
1950-1955	9.5
1955-1960	9.4
1960-1965	9.5
1965-1970	9.6
1970-1975	9.6
1975-1980	9.3

(a) From July 1 of initial year to June 30 of terminal year.
Source: Current Population Reports, Population Estimates, Series P-25, No. 286 (July, 1964), p 27, Table 5.

I-16. Birth Rates

Population projections are particularly sensitive to trends in the crude birth rate (the number of births per thousand females). Fluctuations in this rate are evident in a review of historical statistics. Table 44 presents total live births, adjusted for underregistration, per 1000 population and per 1000 fertile-age women for selected years from 1910 through 1960.

TABLE 44. TRENDS IN LIVE BIRTHS

Year	Live Births Per 1000 Population	Live Births Per 1000 Females Aged 15-44
1910	30.1	126.8
1920	27.7	117.9
1930	21.3	89.2
1940	19.4	79.9
1950	24.1	106.2
1960	23.9	119.0

Source: Health, Education and Welfare Trends, 1961 Edition, U. S. Department of Health, Education, and Welfare, U. S. Government Printing Office, Washington, D. C. p 6.

A number of factors enter into variations in the crude birth rate. For example, many writers have discussed the impact of urbanization, race, economic level, educational attainment, and

economic environment as determinants of changes in the crude birth rates of the population.

Since a thoroughly sophisticated analysis of trends in fertility has been provided by the U. S. Department of Commerce, Bureau of Census, trends in birth rate used in this study were related to trends developed by the U. S. Bureau of Census.* The U. S. Bureau of Census used the "cohort-fertility" method for projecting population. This method is designed to follow male and female population, by age, to each future year, to yield annual population projections by age and sex. This may be contrasted with the "calendar year age-specific" approach used earlier. As stated in the referenced U. S. Census report:

> "Two main advantages of the cohort-fertility approach are (1) that the fertility assumptions can be described in terms of completed fertility of real cohort of women so that unreasonable or unlikely assumptions concerning completed family size may be avoided, and (2) that use can be made of (a) information available on the accumulated fertility to date of each cohort – i.e., how many children women at each age already have had by the beginning of the projection period – and (b) information on the expressed expectations of women regarding completed family size that have been obtained in national sample surveys."

The results of this superior methodology have been used in this study to determine age-specific birth rates for use in projecting population for each of the planning subareas within the Area and the total for the state of Michigan.

The U. S. Bureau of Census provides four projections of fertility. Series B estimates have been selected as the benchmark in this study, since it appears to approximate most closely current experience. Series B is considered by the Bureau of Census to be a moderately high series "...in that it presumes

*Current Population Reports, Population Estimates, "Projections of the Population of the United States by Age and Sex: 1964-1985, With Extensions to 2010", Jacob S. Siegel, Meyer Zitter, and Donald S. Akers, Series P-25, No. 286 (July, 1964).

only a modest drop from the levels of fertility* in the last decade." It is significant to point out that a national sample of married couples conducted in 1955 and 1960 provides estimates that completed family size for all women 18 to 39 years of age would approximate three births per woman.** Series B produces a rate of 3.1 children per woman for those cohorts yet to reach the beginning of their childbearing period. Series C is somewhat below that level (2.775 children per woman), and Series D is based on a rate of 2.450 children per woman.*** Hence, the implicit assumption associated with Series B, as used in this study, is that fertility will approach the expectations of families as indicated by the 1960 survey.

In the current study, birth rates were calculated by age of mother for the subareas, Michigan, and the United States for 1960. Table 45 reports the total resident female population by age group for each of these areas. The total live births by age of mother are reported in Table 46. The table presents data for three age groups of mothers:

(1) 15-19
(2) 20-24
(3) 25-44.

Live births by mothers under 15 years of age are included in the 15-19 age group, and live births by mothers over 44 years of age are included in the 25-44 age group. This was done to develop comparable series between the areas and to simplify calculations. It can be shown that calculations of birth rate are particularly sensitive to populations in these three age groups.

Birth rates by age of mothers, Table 47, were calculated from the data presented in Tables 45 and 46. The Bureau of Census provides estimates and projections of age-specific birth rates for the period 1950-2010****. Projections of birth rates by age of mother were developed for the planning subareas, the Area, and Michigan by relating the 1960 birth rates in each of these areas to the U. S. birth rate shown in Table 47. Hence, projected birth

*The concept of "completed fertility" is used. This refers to the total number of children born, on the average, to each cohort of females.

**"The methods and results of the 1960 survey will be described in a book by the late P. K. Whelpton, A. A. Campbell, and J. E. Patterson, now in preparation."

***Ibid, p. 16. The rate used for Series D is the lowest level experienced by earlier cohorts born during the past several decades. It is the completed fertility rate of cohorts born in 1900-1904.

****Ibid, p. 63.

TABLE 45. TOTAL RESIDENT FEMALE POPULATION BY AGE GROUP FOR THE AREA, MICHIGAN, AND UNITED STATES, 1960

Subarea	15-19 Years	20-24 Years	25-44 Years
Grand Rapids	17,641	14,683	59,968
West Central Belt	4,025	2,996	12,872
Lansing	13,097	11,818	38,137
Northeast Fringe	3,642	2,821	11,183
Jackson	4,670	3,689	16,325
Area	43,075	36,007	138,485
Michigan	287,451	238,363	1,058,552
United States	6,585,582	5,528,421	23,964,970

Source: 1960 Census of Population, Vol I, Characteristics of the Population: Part 1, U. S. Summary, Table 46; Part 24, Michigan, Table 16 and Table 27.

TABLE 46. TOTAL LIVE BIRTHS BY AGE OF MOTHER FOR THE AREA, MICHIGAN, AND UNITED STATES, 1960

Subarea	15-19 Years	20-24 Years	25-44 Years
Grand Rapids	1,237	4,197	6,791
West Central Belt	431	976	1,184
Lansing	992	3,885	3,870
Northeast Fringe	302	876	1,120
Jackson	445	1,164	1,549
Area	3,407	11,098	14,514
Michigan	22,972	65,108	106,976
United States	593,374	1,426,885	2,237,187

Note: Live births by mothers under 15 years of age are included in the 15-19 age group. Live births by mothers over 44 years of age are included in the 25-44 age group.

Sources: U. S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, 1964, Tables 51 and 52.

Michigan Department of Health, Lansing, Michigan, annual records; "Table E7a--Live Births by Place of Residence, Race, and Age of Mother, Michigan, 1960".

TABLE 47. LIVE BIRTHS PER 1000 FEMALES BY AGE OF MOTHER, GRAND RIVER BASIN, MICHIGAN, AND THE UNITED STATES, 1960

Subarea	Life Births Per 1000 Females For Indicated Age Group		
	15-19 Years	20-24 Years	25-44 Years
Grand Rapids	77.7	285.8	113.2
West Central Belt	107.1	325.8	92.0
Lansing	75.7	328.7	101.5
Northeast Fringe	82.9	310.5	100.2
Jackson	95.3	315.5	94.9
Area	79.1	308.2	104.8
Michigan	79.9	273.1	101.1
United States	90.1	258.1	93.4

Note: Live births by mothers under 15 years of age are included in the 15-19 age group. Live births by mothers over 44 years of age are included in the 25-44 age group.

Sources: U. S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, 1964, Tables 51 and 52.

Michigan Department of Health, Lansing, Michigan, annual records; "Table E7a-Live Births by Place of Residence, Race, and Age of Mother, Michigan, 1960".

rates for 1970, 1980, and the period of 1990-2020, as shown in Table 48, are calculated on the basis of Census Series B projections. Projected live births per 1000 population as used in the projection are shown in Table 48.

I-17. Migration

The rate of migration is influenced by a number of factors, including social reorganization in the form of urbanization, family mobility based on job opportunities, and family mobility based on noneconomic considerations.* The basic formulation used in the

*For a recent study of factors affecting the relocation of workers, see Lansing, John B., Mueller, Eva, Ladd, William, and Barth, Nancy, The Geographic Mobility of Labor: A First Report, Survey Research Center, Ann Arbor, Michigan, p 131 (April, 1963). In this study it was shown that economic or occupational reasons were mentioned in 86 per cent of moves of the sample population during the past 5 years, community reasons were mentioned in 21 per cent, and family reasons were mentioned in 24 per cent. In 59 per cent of the survey responses, economic or occupational reasons only were mentioned.

TABLE 48. LIVE BIRTH RATES BY AGE OF MOTHER FOR THE AREA, MICHIGAN, AND UNITED STATES, 1960-2020

	Live Births Per 1000 Population											
	1960			1970			1980			1990-2020		
Subarea	15-19	20-24	25-44	15-19	20-24	25-44	15-19	20-24	25-44	15-19	20-24	25-44
Grand Rapids	40.05	156.22	58.30	34.61	138.46	52.79	34.11	132.11	59.09	33.77	129.02	53.25
West Central Belt	48.92	142.05	45.50	42.22	125.45	41.12	41.62	119.71	46.10	41.18	116.61	41.54
Lansing	38.45	164.35	50.99	33.23	145.49	46.10	32.74	138.79	51.65	32.41	135.41	46.56
Northeast Fringe	41.09	162.80	50.77	35.50	144.23	45.93	35.00	137.57	51.46	34.63	134.32	46.38
Jackson	47.93	155.01	43.33	41.38	137.15	38.97	40.82	130.87	43.82	40.39	127.66	39.44
Area	39.87	157.95	52.55	34.44	139.87	47.51	33.95	133.46	53.23	33.62	130.20	48.00
Michigan	40.71	145.59	51.52	35.17	129.01	46.60	34.67	123.08	52.21	34.34	120.16	47.05
United States	44.50	129.00	47.44	38.42	114.18	42.92	37.87	108.92	48.07	37.50	106.32	43.34

Sources: U. S. Department of Commerce, Bureau of the Census, Current Population Reports, "Population Estimates", No. 286, July, 1964, Table A-2. Series B Projections.

Michigan Department of Health, Lansing, Michigan, annual records, "Table E7a - Live Births by Place of Residence, Race, and Age of Mother, Michigan, 1960".

Battelle projections.

migration analysis of this study is that the direction in magnitude of migration is related to unemployment rates in the regions with respect to unemployment rates in the U. S. As explained in the following section, which describes the four stages of analysis, the initial migration projections were based on assumed unemployment levels in the planning subareas. The original formulation is based on a linear regression analysis of the form

Net migration = A (relative unemployment rate) + B.

The value of the coefficient B, which represents net migration at zero relative unemployment, is a useful index of the relative attractiveness of regions. In generally depressed areas, the coefficient indicates that even at zero relative unemployment (the local unemployment rate equals the national unemployment rate), out migration appears. In contrast, for relatively attractive areas, in migration appears even when relative unemployment levels are zero. This technique is particularly useful, since migration can be related not only to relative unemployment levels, but to age classes. The 20-24 age group is particularly mobile relative to the other age classes of the population. Table 49 summarizes the general pattern of migration between States, as reported by the U. S. Bureau of Census for the period March, 1959, to March, 1960.*

TABLE 49. MIGRANTS BETWEEN STATES, BY AGE, MARCH 1959 - MARCH 1960

Age, Both Sexes, years	Per Cent of Civilian Population That Moved Between States
1-4	4.8
5-6	3.5
7-17	2.3
18-19	4.8
20-24	9.0
25-29	6.1
30-34	3.6
35-44	2.8
45+	Slowly decreases with age from 1.3

Source: U. S. Bureau of the Census, Current Population Reports, Series P-20, No. 113 (January 22, 1962), Table 4.

*Details of the regression relationships are not presented, since, as shown in the following discussion concerning the four stages of analysis, they are not crucial to the final results.

I-18. Summary – Dynamics of Population Change

The preceding sections have indicated the analysis involved in projections of mortality, fertility, and net migration, the three basic determinants of population change (see Figure 4). Further, the discussion concerning migration introduced the relationship between economic growth and population growth, since relative unemployment levels are affected by the regional development of industries. The complexities of the interactions between population, employment level, and migration are illustrated in Figure 5. These interactions are presented in the following sections in terms of the stage-by-stage analysis undertaken during this study, in order to relate the population growth and economic growth.

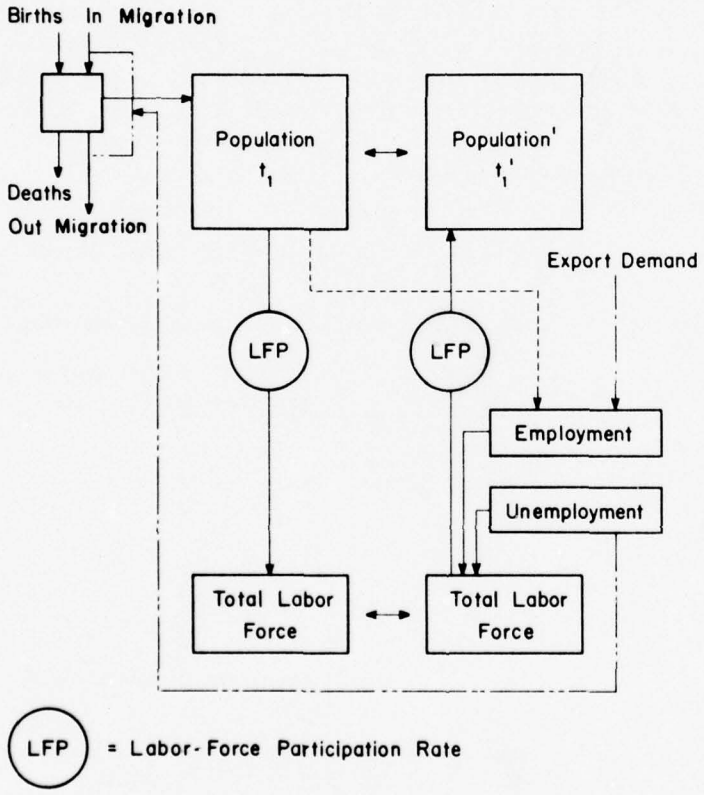

FIGURE 5. POPULATION, EMPLOYMENT, AND MIGRATION FEEDBACKS

I-19. Feedback Analysis

In Figure 5, the dynamics of population change presented in Figure 4 may be introduced to yield population t_1. From this population, it is possible to calculate the total labor force through projecting the labor-force participation ratio. (Generally, this ratio is projected in terms of that portion of the total population of labor-force age, namely, the population 14 years of age and older.) Alternatively, population' and t_1' could be estimated through determining the level of employment and unemployment (total labor force) and the labor-force participation rate.

The population projected through analysis of mortality, fertility, and net migration should be comparable to that estimated on the basis of employment opportunities. The analysis is complex because of two fundamental feedbacks within the system: (1) unemployment rate is important in determining net migration and (2) total population is an important determinant of several sectors of employment, such as wholesale and retail trade. To undertake a systematic analysis of these feedbacks, Battelle's methodology proceeded in terms of four stages, as described below. (See Figure 6.)

Stage I

Initially, a level of unemployment for each of the planning subareas and the state of Michigan was assumed throughout the projection period, and the unemployment-migration relationship was used to derive estimates of net migration. These estimates were combined with the birth rates and death rates, presented earlier, to determine the population.

Stage II

Given the population, employment in those sectors of the economy which are closely related to population was projected. At the same time, employment projections were developed for the major industries that satisfy external demand. These industries include agriculture, mining, most manufacturing industries, and selected services, such as educational services and public administration. As a result of these estimates and projections, total employment in each of the subareas and the Area are developed.

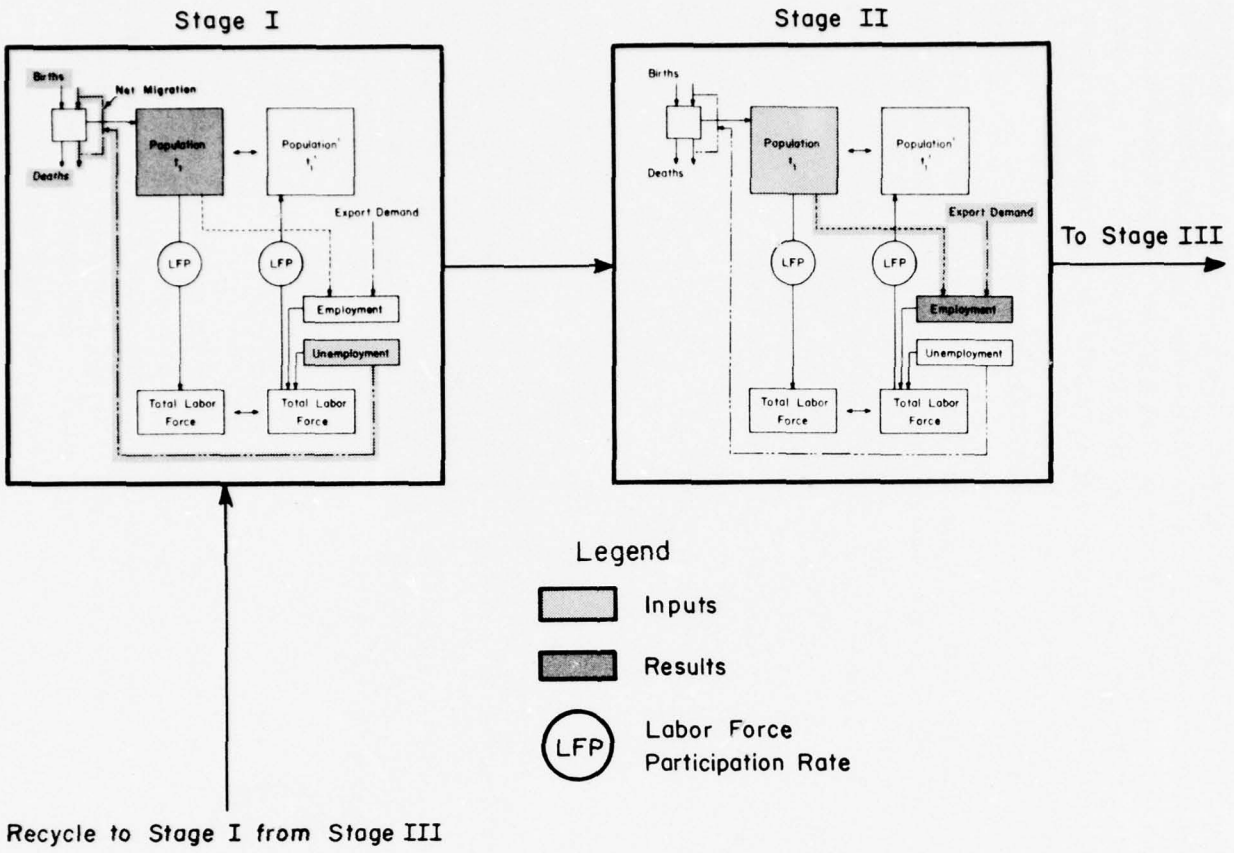

FIGURE 6. ANALYSIS STAGES FOR POPULATION PROJECTIONS

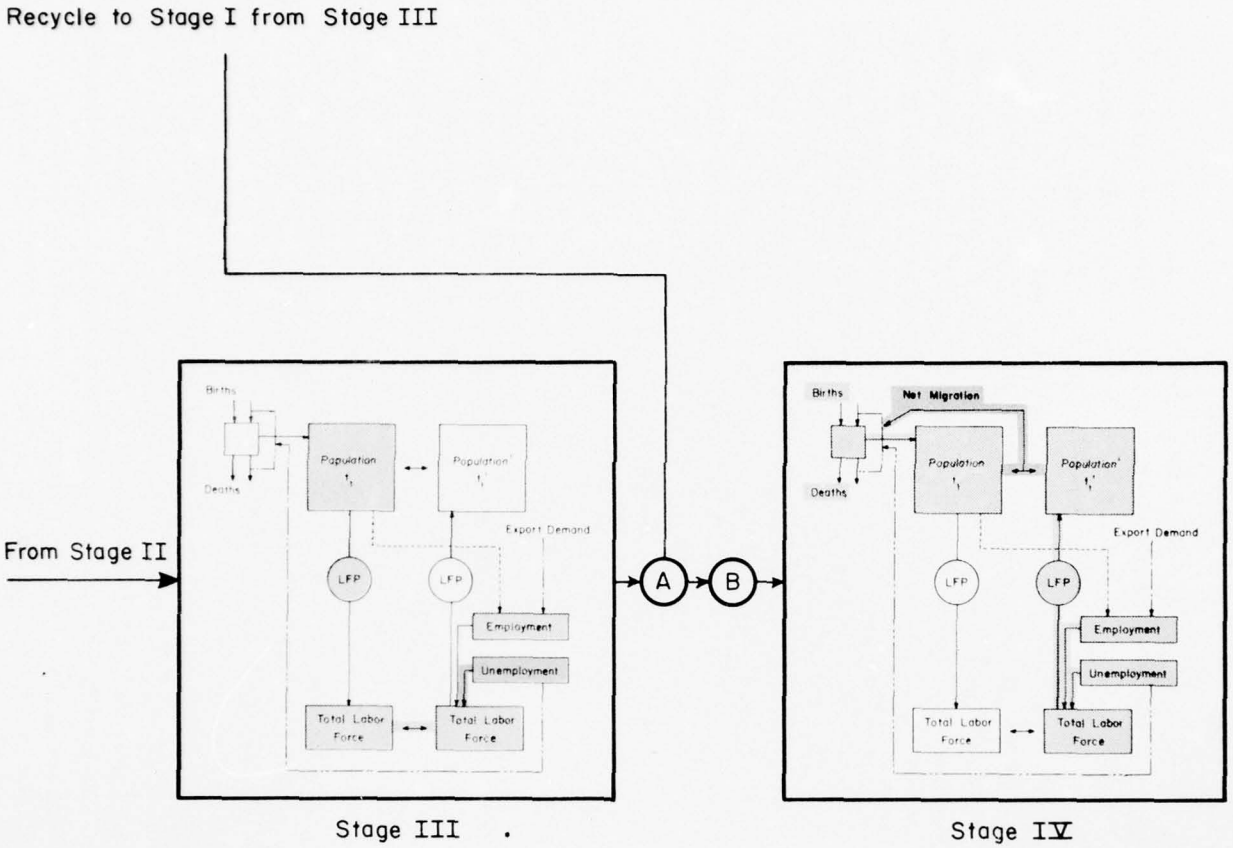

FIGURE 6. (CONTINUED)

Stage III

As the result of Stages I and II, the total labor force may be calculated through analysis of labor-force participation. The total labor force calculated may be compared with the employment level projected, with the difference between the two estimates being defined as unemployment. Alternatively, the unemployment rate assumed in Stage I could be implemented in Stage III to yield an independent estimate of total labor force. If the total labor force estimated through the employment projection and the assumed unemployment rate (Stage II) is equal to the total labor force derived from the population through labor force participation (Stage III), the system is in balance. If such a result is obtained as a result of the first set of assumptions, the analysis could proceed to Stage IV. Most likely, the result of Stage III will be a need to recycle through A, with the calculated unemployment rate (resulting from the difference between projected employment levels and projected total labor force) used to derive a second estimate of migration in Stage I. Employment levels are recalculated (Stage II) and calculated versus assumed unemployment levels are compared again (Stage III) until the system is in balance.

Stage IV

The result of a mechanical recycling of Stages I, II, and III yields the complete set of data required. However, mechanical methodologies, if used for long-term projections, frequently yield unreasonable results, even though the numerical characteristics may be in balance. For example, the distribution of projected employment and population among the subareas may be unreasonable. As a result, Stage IV is introduced to permit judgmental adjustments of the results in a balanced manner.

To illustrate the character of the adjustments, reference is made to the section of this report dealing with employment by subarea. A judgmental adjustment was introduced to constrain the growth of the non-metropolitan areas (West Central Belt and Northeast Fringe Planning Subareas) relative to the metropolitan subareas. Given the fundamental characteristics of these planning subareas, this judgment is reasonable. In other words, relative growth of manufacturing industries which has occurred in the non-metropolitan subareas may be interpreted as a "catching-up"

process which is unlikely to continue in a manner which would result in their eventual domination of manufacturing employment. At the conclusion of the judgmental adjustments in employment and hence in population, Stage IV introduces a series of calculations to explicitly set forth the ramifications of the judgmental adjustments. Population was initially estimated in terms of mortality, fertility, and net migration. In Stage IV, population is recalculated in terms of natural increase only (mortality and fertility). Population' is calculated through the employment-unemployment – total-labor-force projections, using labor-force participation rates. The projected population is compared with the natural-increase population estimated previously, with the divergence being accounted for by net migration. The level of net migration for each of the subareas and the Area is shown in Table 50. The decade by decade migration rate calculated on the basis of population level at the beginning of the decade is shown in Table 51. As a result of the relatively high birth rate in the Area, the Area and subareas show net out migration as well as a substantial population growth. The final population estimated for the subareas is shown in Figure 7, and in Table 52. The total resident population for Michigan and the United States is shown in Figure 8. The projected relationships between population, labor force, and employment for the Area are shown in later sections of this report.

I-20. Population and Households

The methodology used in projecting household population within the Area is nearly identical to that used for projecting the number of households and average size of household for the United States. Application of this methodology to the projected population for the State, the Area and the subareas yields the projections of average size of household and number of persons living in households set forth in Table 53.

One modification in the methodology used for the United States is necessitated by the differences in proportion of population in households in the subareas and the reasons underlying these differences. There are three institutions in the Area which result in disproportionately high non-household populations: the State prison in the Jackson area, the Ionia reformatory in the West Central Belt, and the Michigan State University in the Lansing subarea. The presence of each of these institutions requires additional assumptions with regard to the proportion of total population which will be living in households in the future. For purposes of these

TABLE 50. PROJECTED NET OUT MIGRATION BY SUBAREA BY DECADE

	Number of Persons					
	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010	2010-2020
Grand Rapids	7,064	8,356	11,923	15,100	22,304	38,588
West Central Belt	2,471	5,360	8,328	11,071	13,473	17,897
Lansing	3,705	2,081	4,975	6,136	12,644	24,974
Northeast Fringe	3,849	4,846	6,176	7,451	10,034	13,480
Jackson	2,436	3,846	3,887	3,971	8,151	12,903
Area	19,525	24,489	35,289	43,729	66,606	107,842

Source: Battelle calculations.

TABLE 51. PROJECTED PER CENT NET OUT MIGRATION BY SUBAREA BY DECADE

	Per Cent of Initial Population Each Decade					
	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010	2010-2020
Grand Rapids	1.5	1.6	1.9	2.0	2.5	3.6
West Central Belt	2.2	4.3	5.8	6.8	7.3	8.6
Lansing	1.2	0.6	1.1	1.2	2.0	3.4
Northeast Fringe	4.3	4.8	5.3	5.6	6.5	7.7
Jackson	1.8	2.5	1.6	1.9	3.3	4.4
Area	1.8	1.9	2.3	2.4	3.1	4.3

Source: Battelle calculations.

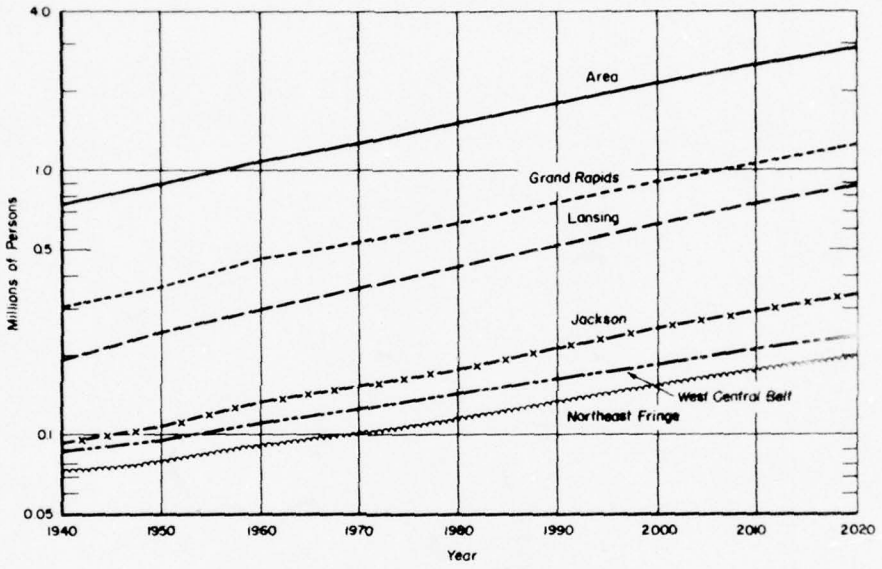

FIGURE 7. TOTAL RESIDENT POPULATION FOR SUBAREA AND AREA, 1940-2020

Sources: 1950 Census of Population, Vol II, Characteristics of the Population, Part 22, Michigan, Tables 1 and 7.

1960 Census of Population, Vol I, Characteristics of the Population, Part 24, Michigan, Tables 1 and 6.

1970-2020 Battelle projections.

TABLE 52. POPULATION OF UNITED STATES, MICHIGAN, AREA AND SUBAREAS, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
United States	179,325,671	208,996,000	245,313,000	288,219,000	338,219,000	399,256,000	470,442,000
Michigan	7,823,194	8,954,000	10,413,000	12,177,000	14,238,000	16,593,000	19,103,000
Per Cent of U. S.	4.36	4.28	4.24	4.22	4.21	4.15	4.06
Area	1,093,972	1,272,100	1,505,800	1,788,100	2,115,600	2,485,700	2,881,000
Per Cent of Michigan	13.98	14.21	14.40	14.68	14.86	14.98	15.08
Subareas							
Grand Rapids	461,900	535,500	635,600	757,500	900,100	1,065,100	1,242,600
Per Cent of Area	42.23	42.09	42.21	42.37	42.54	42.85	43.13
West Central Belt	110,700	125,500	142,800	162,600	184,000	208,700	233,300
Per Cent of Area	10.11	9.87	9.48	9.09	8.70	8.40	8.10
Lansing	298,900	358,600	434,800	522,700	626,600	743,100	867,600
Per Cent of Area	27.32	28.16	28.88	29.23	29.62	29.89	30.11
Northeast Fringe	90,500	100,400	115,600	133,700	154,200	176,100	198,800
Per Cent of Area	8.28	7.89	7.68	7.48	7.29	7.08	6.90
Jackson	132,000	152,100	177,000	211,600	250,700	292,700	338,700
Per Cent of Area	12.06	11.96	11.75	11.83	11.85	11.78	11.76

Sources: United States projections 1970-2010 are from the U. S. Department of Commerce, Bureau of the Census, Current Population Reports: "Population Estimates", Series P-25, No. 286 (July, 1964), Table 4, Series B. Other Projections are by Battelle Memorial Institute.

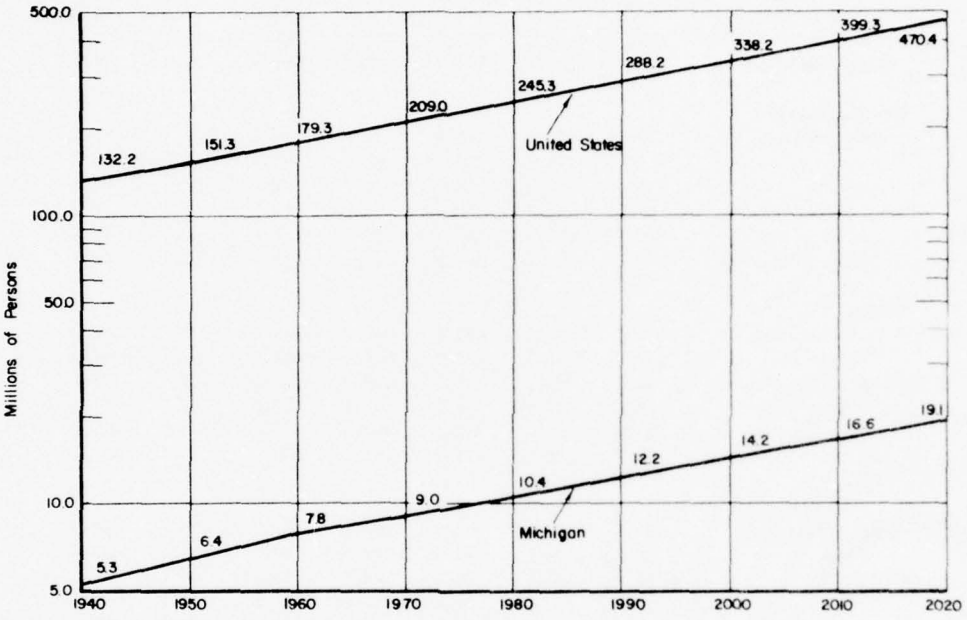

FIGURE 8. TOTAL RESIDENT POPULATION OF MICHIGAN AND THE UNITED STATES, 1940-2020

Sources: 1960 Census Population, Vol I, Characteristics of the Population: Part I, U.S. Summary, Table 2; Part 24, Michigan, Table 1.

1970-2020 Battelle projections.

TABLE 53. URBAN, RURAL, FARM AND HOUSEHOLD POPULATION OF AREA AND SUBAREAS, 1960-2020

Area	Thousands of Persons or Households						
	1960	1970	1980	1990	2000	2010	2020
Grand Rapids							
Total population	461.9	535.5	635.6	757.5	900.1	1,065.1	1,242.6
Urban	351.5	415.0	500.9	606.0	728.2	870.2	1,022.7
Rural	110.4	120.5	134.7	151.5	171.9	194.9	219.9
Rural-farm	22.6	15.0	12.5	10.8	9.4	8.0	6.8
In households	454.2	526.4	624.8	744.6	884.8	1,045.0	1,221.5
Number of households	133.2	147.7	174.0	207.4	246.5	291.6	340.2
West Central Belt							
Total population	110.7	125.5	142.8	162.6	184.0	208.7	233.3
Urban	36.4	49.2	64.1	81.1	99.5	120.8	141.8
Rural	74.3	76.3	78.7	81.5	84.5	87.9	91.5
Rural-farm	25.2	21.5	18.5	15.5	12.8	11.0	9.5
In households	106.9	121.0	137.7	156.7	177.4	201.2	224.6
Number of households	31.8	33.9	37.8	43.1	48.8	55.3	61.8
Lansing							
Total population	299.0	358.6	434.8	522.7	626.6	743.1	867.6
Urban	202.7	254.2	319.6	395.2	484.4	584.8	691.5
Rural	96.3	104.4	115.2	127.5	142.2	158.3	176.1
Rural-farm	29.6	25.5	22.2	18.5	15.4	13.3	11.5
In households	287.0	330.3	394.8	480.9	581.5	697.0	820.7
Number of households	85.1	93.2	111.4	135.7	164.1	196.7	231.2
Northeast Fringe							
Total population	90.5	100.4	115.6	133.7	154.2	176.1	198.8
Urban	43.3	51.0	64.0	79.6	97.3	116.0	135.6
Rural	47.2	49.4	51.6	54.1	56.9	60.1	63.2
Rural-farm	20.0	17.4	15.2	12.9	11.1	9.8	8.6
In households	89.1	98.9	113.9	131.7	151.9	173.5	198.5
Number of households	26.0	28.3	32.5	37.6	43.4	49.6	56.0
Jackson							
Total population	132.0	152.1	177.0	211.6	250.7	292.7	338.7
Urban	90.9	108.3	129.7	159.3	193.0	229.2	268.6
Rural	41.1	43.8	47.3	52.3	57.7	63.5	70.1
Rural-farm	8.5	8.0	6.9	5.7	4.7	4.0	3.5
In households	124.9	144.9	169.9	204.5	243.6	285.6	331.6
Number of households	37.5	39.8	45.2	54.4	64.9	76.0	88.3
Area							
Total population	1,094.0	1,272.1	1,505.8	1,788.1	2,115.6	2,485.7	2,881.0
Urban	724.8	877.7	1,078.3	1,321.2	1,602.4	1,921.0	2,260.2
Rural	369.2	394.4	427.5	466.9	513.2	564.7	620.8
Rural-farm	105.9	87.3	75.3	63.4	53.4	46.1	39.9
In households	1,062.1	1,221.5	1,441.1	1,718.4	2,039.2	2,402.3	2,796.9
Number of households	313.6	343.0	401.0	478.3	567.6	669.2	777.9

Sources: 1960: U. S. Bureau of the Census; 1970-2020 Battelle projections; Economic Research Service, U. S. Department of Agriculture.

Notes: Detail may not add to total due to rounding.

projections, it has been assumed that the absolute level of population not in households in Ionia County (the location of the reformatory) will grow as a constant proportion of the population of the states and that the nonhousehold population in the Jackson subarea will remain numerically constant over the projection period, reflecting the presumption that the prison will not expand appreciably. With regard to the Lansing subarea, a projection of the enrollment at Michigan State University has been undertaken, and the projected rate of growth of the University has been applied to the nonhousehold population in the Lansing subarea in order to project its absolute level over the projection period.

To project enrollment in the University, it is necessary to examine the present and past enrollment data. The Michigan State Department of Public Instruction has provided data for the fall enrollment of Michigan State University from 1961 through 1964 (estimated). These data show enrollment increasing from 26,034 students in 1961 to an estimated 31,700 students in 1964. The official head-count enrollment for fall of 1964, as reported on the annual Institution Report of December 8, 1964, showed an enrollment of 34,932.

In 1961 an enrollment projection for Michigan State University was prepared by Professor J. F. Thaden*. His projection showed a growth in enrollment to over 42,000 students by 1970. Thaden's projections are based on 1961 actual reported enrollments, which were only 87 per cent of the fall enrollment reported by the Michigan Department of Public Instruction. Further, Thaden's projections appear to be very conservative – his projected enrollment for the fall of 1964 was 25,360, which is 80 per cent of the 31,700 estimated fall enrollment.

Setting aside the discrepancies in enrollment estimates and examining decade trends, Thaden projected an increase of 86 per cent in enrollment between 1961 and 1970, which compares with the projected increase of 80 per cent reported by the U. S. Office of Education for the Nation and a projected increase of 92 per cent for the State of Michigan reported by Ronald B. Thompson**. Thaden projects an increase of 66 per cent in Michigan State University for the period 1964-1970, Thompson projects an increase of 60 per cent in Michigan higher education, and the U. S. Office of Education projects an increase of 46 per cent for total U. S. enrollment in higher education.

*Thaden, J. F., "Projection of Potential Enrollment at Michigan State University to 1970" (September 8, 1961). Unpublished.

**Thompson, Ronald B., Enrollment Projections for Higher Education, 1961-1978, The American Association of Collegiate Registrars and Admissions Officers (September, 1961).

Recognizing these diverse trends and the physical limitations likely to be imposed on any college campus, Battelle's projected enrollment for Michigan State University in 1970 was calculated to equal an increase of 65 per cent over the estimated enrollment of 1964 to a level of 52,300. Because of the physical limitations and constraints on main campus size, this enrollment is less than could be projected purely on the basis of population profile and trends in increasing enrollment. The projection for 1980 is an enrollment of 73,000 students; however, it is anticipated that while many of these students may be in the subarea, they are likely to be located somewhere other than on the main campus.

While 73,000 students appears to be an extraordinarily large enrollment, it will not be adequate to meet the needs of expanding population and the desire of an increasing proportion of the population to attend college. If Michigan State University grew 60 per cent between 1980 and 2020, a growth which is less than the 74 per cent population growth anticipated in the Area and the 83 per cent growth anticipated in Michigan, total enrollment would equal 125,000. Battelle's projection is that by 1990, enrollment will increase only slightly to 75,000, and that from the year 2000 to the year 2020, enrollment will remain at the 80,000 level, reflecting policy to limit the size of any individual institution.

I-21. Urban-Rural Population

Urban population is defined by the Bureau of the Census as those persons living in places of 2,500 inhabitants or more, the densely settled urban fringe, counties with a population density of 1,500 inhabitants or more per square mile, and unincorporated places of 2,500 inhabitants or more per square mile. The farm population is defined as those living in rural territories on places of 10 or more acres from which sales of farm products amounted to $50 or more in 1959, or on places of less than 10 acres from which sales of farm products amounted to $250 or more in 1959. Persons living in rural areas but not on farms (as defined), are classified as rural nonfarm.

As Table 54 and Figure 9 reveal, the United States population has experienced a secular increase in urbanization from 1790 to 1960. The rate of this increase was 31.8 per cent per decade from 1850 to 1900, 9.7 per cent per decade from 1900 to 1950, and

TABLE 54. URBAN AND RURAL POPULATION OF THE UNITED STATES, SELECTED YEARS, 1790-1960

Year	Thousands of Persons			Per Cent of Total Population	
	Total	Urban	Rural	Urban	Rural
1790	3,930	202	3,728	5.1	94.9
1850	23,192	3,544	19,648	15.3	84.7
1900	75,995	30,160	45,835	39.7	60.3
1950	150,697	88,927	61,770	59.0	41.0
1960	179,323	113,056	66,267	63.0	37.0

Source: U. S. Department of Commerce, Bureau of the Census, U. S. Summary PC (1). 1960.

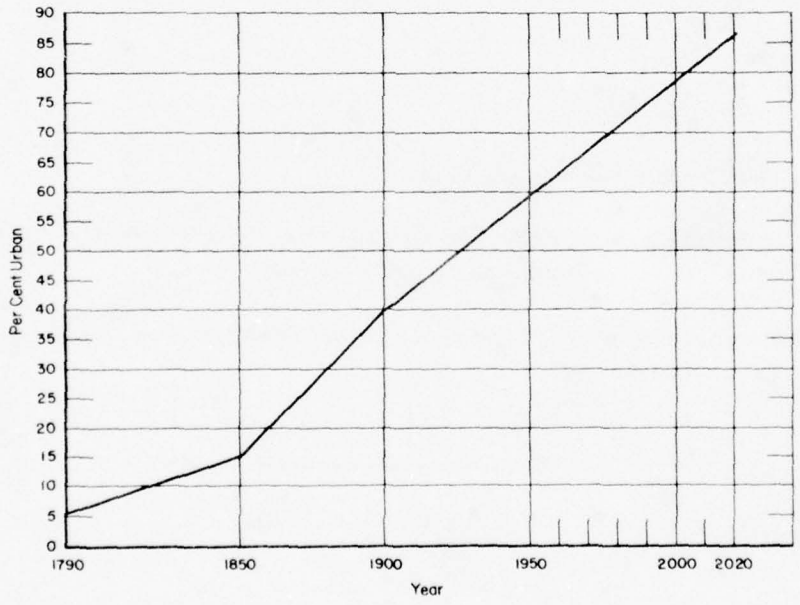

FIGURE 9. TREND IN PER CENT URBAN POPULATION OF THE UNITED STATES, 1790-1960, AND PROJECTION TO 2020

6.77 per cent from 1950 to 1960. Thus, it is evident that this trend in urbanization continues, but at a declining rate.

For the purpose of this projection, it is observed that changes in the degree of urbanization of a subarea were a function of changes in the population density (number of people per square mile) of that subarea. Table 55 shows the relationship between population density and urban-rural distribution of population.

The following equation was used to define the urbanization-density relationship:

$$Y = a - \frac{b}{x},$$

where

Y = per cent urban

x = population density

b = constant

a = asymptotic limit of Y.

The above equation was selected because it closely fits the data, and the value of its asymptotic is reasonable.

The values of a and b were calculated through a regression analysis as shown below:

$$b = \frac{\sum \left[Y - \overline{Y} \right] \left[(1/x) - (\overline{1}/x) \right]}{\sum \left[(1/x) - (\overline{1}/x) \right]^2}$$

$$a = \overline{Y} - b \left[\overline{1}/x \right]$$

$$a = 86$$

$$b = 3200$$

$$R^2 = 0.79$$

$$Y = 86 - \frac{3200}{x} \quad .$$

TABLE 55. POPULATION DENSITY AND PER CENT URBANIZATION, 1960

Subarea	Population Per Square Mile	Per Cent Urban
Grand Rapids	323.9	74.0
West Central Belt	60.3	26.0
Lansing	176.1	67.3
Northeast Fringe	81.8	42.5
Jackson	187.2	57.6
Area	161.6	62.7
Michigan	134.2	73.4
United States	58.2	69.9

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 37 and 91.

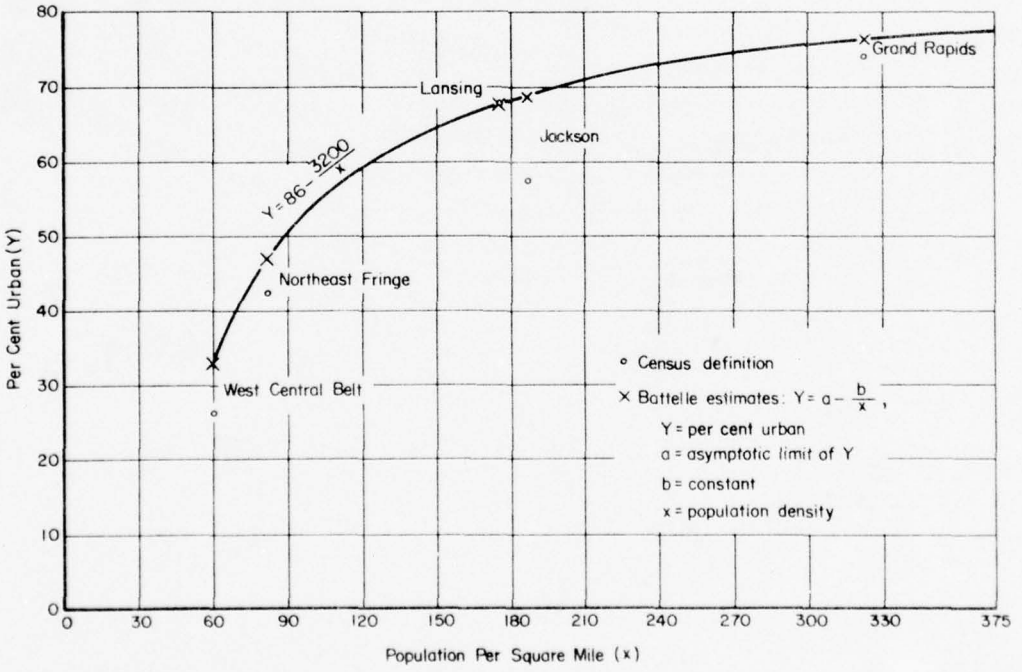

FIGURE 10. PER CENT URBANIZATION AND POPULATION DENSITY FOR AREA, 1960

The graph of the above equation, upon which the urbanization projection is based, is shown in Figure 10. The relationship between population density and relative degree of urbanization was primarily observed on a subarea basis in the Grand River Basin.

Application of the values for per cent urban from this function are used to derive the rural and urban population estimates set forth in Table 53. Total population divided by area (e.g. density) for each subarea was derived from the population estimates and degree of urbanization thereby derived.

SECTION E. GRAND RIVER BASIN: EMPLOYMENT PROJECTIONS FOR THE AREA AND SUBAREAS (1960-2020)

Previous sections have set forth the historical and projected data on population, households, the urban and rural composition of the population in the future, and the rural farm and rural nonfarm breakdown of population. This section contains the projected employment levels, labor-force size, and unemployment levels, and the detailed projections of employment by major industry and key industry in the Area and appropriate subareas.* As indicated earlier in this report, the detailed projections for the Area are made within the context of the Battelle socioeconomic model.

I-22. Educational Attainment

Educational-attainment data for the Area are not available in sufficient detail or for enough years to permit an independent projection of educational attainment of the population presently living in the Area or for the population projected to live there in the future. Consequently, it is necessary to rely on educational-attainment data for the population of Michigan to estimate future levels of educational attainment for the population of the Area. The method used to project levels of educational attainment through 1980 for the United States is set forth in a previous section. The same method is used to project educational-attainment changes for the population in Michigan (and thereby the Area).

I-23. Labor Force

Projections of the labor force within the context of the model were made only for the entire area. Subsequently, these projections were allocated among the various subareas. These allocations are discussed below.

An analysis of national historic trends in labor-force participation rates by levels of education and by age was undertaken in order to project the labor force from the projected supply (the population) in terms of educational attainment. The methodology used for this projection for the Area parallels the analysis previously described for the national projections; the same participation

*Because of the importance of the manufacturing industry, detailed analysis is presented in a separate, following major section.

rates by levels of education are used for the Area as for the Nation. Application of these participation rates results in a projected labor force for the Area. In 1960, the average labor-force participation rate in the Area was 55.5 per cent, and the rates for 1970 and 1980 are projected as 55.8 per cent and 55.0 per cent, respectively. Similar analysis at the State level indicates a slight decrease in the labor-force participation rate between 1960 and 1970 from 55.0 per cent to 54.6 per cent, with a rate of 55.4 per cent projected for the state by 1980.

The labor-force participation rates during the period 1990 through 2020 for both the State and the Area are based on an analysis of 1960-80 trends in the rates in conjunction with the employment opportunities expected to exist in each geographic region between 1990 and 2020. This analysis leads us to project the Area's labor-force participation rate as declining from 55.0 per cent in 1980 to 51.5 per cent by 2020. The State is expected to experience a corresponding decline from 55.4 per cent in 1980 to 53.4 per cent in 2020. These projected declines reflect Battelle's conclusions that (1) early retirement will become more prevalent and (2) young people will devote progressively more time to receiving an education, thereby delaying their entry into the labor force. We also expect trends in labor force participation to be affected by the growing necessity for people in prime age groups to leave the labor force from time to time to undertake retraining to raise their skill levels and capabilities to meet the demands of increasingly complex technologies.

In 1960, there were 413.5 thousand people in the labor force in the Area. By 1980, the labor force of the Area will rise to over 575 thousand. By 2020, there should be more than 1 million in the Area's labor force. At the same time, the size of Michigan's labor force in the state will also be growing at a rapid rate – from nearly 3 million in 1960 to over 4 million in 1980; by 2020, over 7 million persons will be holding or seeking jobs in the State. These data, as well as additional data pertaining to employment and unemployment, are set forth on Table 56 for the State and Table 57 for the Area. Employment projections are shown graphically for Michigan and the United States in Figure 11 and for the Area and subareas in Figure 12.

Labor force figures for the subareas were projected by combining separate subarea estimates of employment and of unemployment. (By definition, the sum of employed plus unemployed equals

TABLE 56. ADULT POPULATION, LABOR FORCE, AND EMPLOYMENT IN MICHIGAN, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Total Population (14 and Over), thousands	5,350	6,279	7,276	8,500	9,961	11,652	13,414
Labor-Force Participation Rate, per cent	54.8	54.6	55.4	54.2	53.4	53.7	53.4
Civilian Labor Force, thousands	2,930	3,428	4,031	4,607	5,319	5,657	7,163
Employment, thousands	2,727	3,222	3,769	4,363	5,064	6,007	6,876
Unemployment, thousands	203	206	262	244	255	250	287
Unemployment Rate, per cent	6.9	6.0	6.5	5.3	4.8	4.0	4.0

Source: 1960: U. S. Department of Commerce, Bureau of the Census, U. S. Census of Population: 1960, Volume I, Characteristics of the Population, Part 24, Michigan, Table 52.

1970-2020: Battelle estimates.

TABLE 57. ADULT POPULATION, LABOR FORCE, AND EMPLOYMENT IN THE AREA, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Total Population (14 and Over), thousands	745.7	886.4	1,047.9	1,243.9	1,476.5	1,742.9	2,020.1
Labor Force Participation Rate, per cent	55.4	55.8	55.0	54.4	52.7	51.6	51.5
Civilian Labor Force, thousands	413.1	494.5	575.4	677.0	778.5	900.1	1,040.0
Employment, thousands	392.0	471.9	549.5	648.6	747.2	864.1	998.3
Unemployment, thousands	21.1	22.6	25.9	28.4	31.3	36.0	41.7
Unemployment Rate, per cent	5.1	4.6	4.5	4.2	4.0	4.0	4.0

Source: 1960 Census of Population, Volume I, Characteristics of the Population, Part 24, Michigan.

1970-2020: Battelle projections.

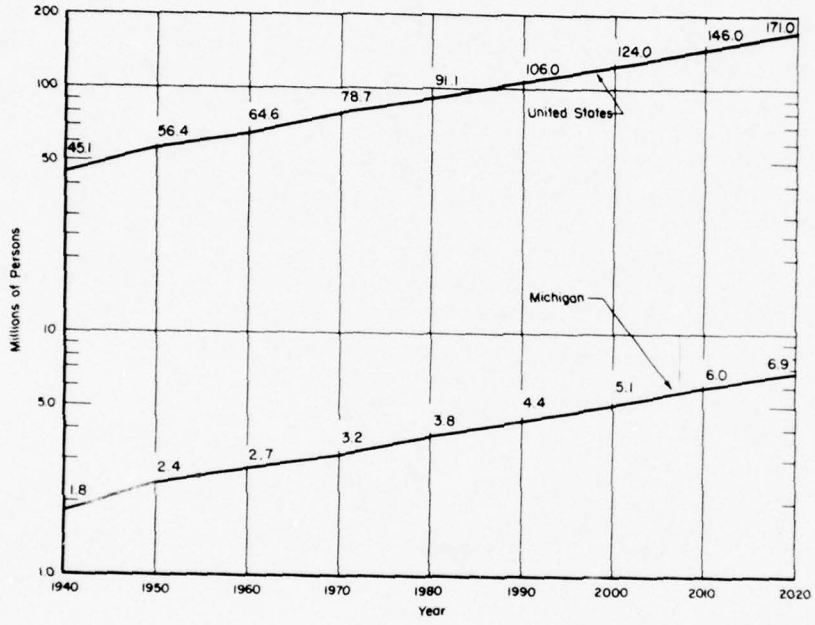

FIGURE 11. TOTAL EMPLOYED IN MICHIGAN AND THE UNITED STATES, 1940-2020

Sources: 1960 Census of Population, Vol I, Characteristics of the Population: Part 1, U.S. Summary, Table 92; Part 24, Michigan, Table 62.

1970-2020 Battelle projections.

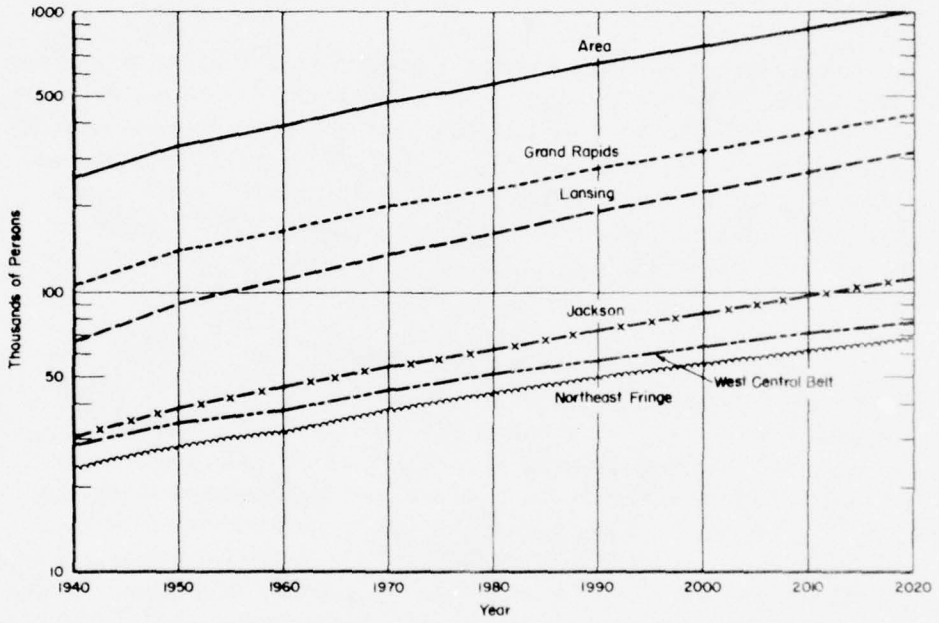

FIGURE 12. TOTAL EMPLOYED IN THE SUBAREAS, 1940-2020

Sources: 1940 Census of Population, Vol II, Characteristics of the Population, Part 3, Michigan, Tables 18 and 23.

1950 Census of Population, Vol I, Characteristics of the Population, Part 22, Michigan, Tables 30 and 43.

1960 Census of Population, Vol I, Characteristics of the Population, Part 24, Michigan, Tables 61 and 85.

1970-2020 Battelle projections.

total labor force.) The methodology underlying the projections of employment for the Area as well as the individual subareas and for unemployment in the Area and each subarea is described in a subsequent section.

I-24. Employment

The State

Employment projections for the state of Michigan are made for the entire forecast period from 1960 to 2020. These projections, undertaken within the context of the socioeconomic model, represent an aggregation of major industry division employment projections, an analysis of the available supply of labor in the state, assumptions with regard to future likely levels of unemployment (in light of projected public policy), and a detailed analysis of the future of the motor-vehicle and equipment industry.

The employment estimates for the State are in Table 56. In 1960, there were approximately 2.7 million employed in Michigan. In the same year, approximately 200 thousand were unemployed; as a result, unemployment stood at 6.9 per cent of the labor force. By 1970 employment in the State is projected to increase to approximately 3.2 million. Unemployment will also rise but at a much lower rate, so that by 1970 the State is projected to experience an unemployment rate of 6.0 per cent. This rate, high by most current standards, reflects a recognition of the fact that by 1970 large numbers of young people will enter the labor force in the State. These people, whose training will be insufficient in light of technological demands, are expected to experience difficulty in obtaining jobs, but are not expected to migrate from the State to an extent sufficient to lower the unemployment rate. The experience of Michigan will be duplicated in most other States, so there is little likelihood of better job opportunities for these workers as a result of migration.

The same trend is anticipated to continue into 1980 for the State as a whole. While employment will increase from the 1970 level of approximately 3.2 million to nearly 3.8 million, unemployment will continue to rise rapidly. It is projected that there will be 260 thousand unemployed in the State in 1980, an unemployment rate of 6.5 per cent.

Between 1980 and 1990 Federal as well as State programs should begin to reduce levels of unemployment. These programs probably will combine training and retraining programs with an expansion of social programs aimed at encouraging workers (particularly those beyond 45 years of age) to leave the labor force if and when inadequate skills make it difficult for them to find jobs.

In view of the likelihood of this expansion of State-Federal programs, a decline in Michigan's unemployment rate to 5.3 per cent is projected by 1990. At the same time and for the same reasons, labor-force participation rates probably will decline. Thus, between 1990 and 2020, unemployment rates are expected to fall, reaching 4.0 per cent by 2010. However absolute employment in the State is projected to increase from approximately 4.4 million jobs in 1990 to nearly 6.9 million in 2020.

The Area

Projections of Michigan employment have been made principally to provide a framework for analyzing in depth the economic future of the Area, and especially its likely future patterns of industry employment. The details of these analyses follow. Resulting projections of employment in the Area's industries are set forth in Table 58. Table 59, in which each industry's 1960 level of employment is taken as 100 per cent, shows the expected rates of growth over subsequent decades, and each year's total projected employment is distributed percentagewise over the several industries in Table 60.

Agriculture. The Economic Research Service of the U. S. Department of Agriculture has provided the employment estimates for agriculture. In 1960, slightly more than 20 thousand persons were employed in agriculture in the Area. By 1980, agricultural employment is estimated to decline to 17.1 thousand and by 2020 to 14.5 thousand.

Mining. During the past decade, mining employment in the Area increased as a result of increased sand and gravel production and new discoveries of petroleum. This trend is expected to continue during the projection period primarily due to the continually increasing demand for sand and gravel.

TABLE 58. EMPLOYMENT BY INDUSTRY IN THE AREA, 1960-2020

Industry	Thousands of Persons Employed						
	1960	1970	1980	1990	2000	2010	2020
Agriculture[a]	20.3	19.6	17.1	16.4	16.1	15.1	14.5
Mining[b]	0.8	0.7	0.7	0.8	0.9	1.1	1.3
Construction	20.4	23.6	27.6	32.5	38.0	45.1	52.0
Manufacturing	134.7	157.9	172.8	190.7	206.1	219.8	229.5
Durable manufacturing	107.8	126.9	137.5	151.0	161.4	169.0	172.8
Timber and wood products[c]	1.6	1.8	1.9	2.4	2.9	3.6	4.2
Furniture and fixtures	9.2	11.1	10.7	10.5	10.2	10.0	9.8
Household furniture	5.2	4.6	4.5	4.8	4.9	5.0	5.0
Office furniture	1.6	3.0	2.9	2.7	2.6	2.3	2.1
Public-building furniture	1.6	2.7	2.6	2.4	2.1	2.1	2.1
Other furniture	0.8	0.8	0.7	0.6	0.6	0.6	0.6
Stone, clay, and glass products	2.4	2.9	3.1	3.2	3.3	3.4	3.5
Abrasive products	0.7	1.1	1.2	1.3	1.4	1.4	1.5
Primary metals	6.2	9.0	9.5	9.4	9.2	9.1	8.9
Miscellaneous primary metals	2.0	2.4	2.6	2.7	2.8	2.9	3.0
Iron and steel forgings	2.0	2.4	2.6	2.7	2.8	2.9	3.0
Other primary metals	4.2	6.6	6.9	6.7	6.4	6.2	5.9
Fabricated metal products	16.1	17.1	16.6	16.9	16.9	16.9	17.1
Cutlery, hand tools, and general hardware	4.0	4.2	3.8	4.2	4.4	4.6	4.8
Metal stampings	4.8	5.4	5.9	6.3	6.6	6.9	7.5
Other fabricated metals	7.3	7.5	6.9	6.4	5.9	5.4	4.8
Machinery, except electrical	18.7	17.8	20.2	20.5	21.1	21.3	22.0
Metalworking machinery	6.5	6.4	8.3	9.1	10.0	10.8	11.8
Special dies and tools	3.6	3.5	4.3	5.0	5.6	4.6	6.9
Other nonelectrical	12.2	11.4	11.9	11.4	11.1	10.5	10.2
Electrical machinery	7.4	15.9	19.9	23.9	27.5	30.2	32.1
Electrical industrial apparatus	2.2	4.3	5.4	6.4	7.4	8.6	10.0
Motors and generators	1.8	3.5	4.3	5.3	6.5	7.9	9.6
Household appliances	4.0	5.5	5.3	5.3	5.2	5.1	5.0
Other electrical machinery	1.2	6.1	9.2	12.2	14.9	16.5	17.1
Transportation equipment	38.7	40.2	43.5	44.6	45.0	46.0	46.0
Motor vehicles	36.1	36.4	38.5	39.3	39.0	39.4	39.0
Other transportation equipment	2.6	3.8	5.0	5.3	6.0	6.6	7.0
Professional instruments	4.4	3.0	3.1	3.2	3.4	3.5	3.6
Scientific instruments	4.2	2.7	2.7	2.7	2.7	2.8	2.8
Other instruments	0.2	0.3	0.4	0.5	0.7	0.7	0.8
Other durable manufacturing	3.1	8.1	9.0	16.4	21.9	25.0	25.6
Nondurable manufacturing	26.9	31.0	35.3	39.7	44.7	50.8	56.7
Food and kindred products	8.9	9.5	9.9	10.5	11.0	11.6	12.2
Bakery products	3.6	3.8	3.9	3.9	4.0	4.1	4.2

TABLE 58. (Continued)

Industry	Thousands of Persons Employed						
	1960	1970	1980	1990	2000	2010	2020
Paper and allied products[c]	1.1	1.2	1.2	1.3	1.4	1.5	1.6
Leather products	2.3	2.8	2.9	2.9	2.9	2.9	2.9
Footwear	1.2	1.5	1.5	1.6	1.6	1.7	1.8
Printing and publishing	6.4	6.0	5.8	6.3	7.2	8.1	8.6
Rubber and plastic products	2.4	3.5	4.7	5.0	5.6	6.2	7.0
Tires and inner tubes	1.6	1.1	0.9	0.8	0.7	0.6	0.5
Other rubber products	0.8	2.4	3.8	4.2	4.9	5.6	6.5
Other nondurable manufacturing	5.8	8.0	10.8	13.7	16.6	20.5	24.4
Transportation	12.2	13.3	14.8	16.4	18.2	20.2	22.7
Communications	4.8	4.5	4.9	5.2	6.0	6.8	7.9
Utilities	5.8	6.3	6.9	7.3	7.8	8.2	8.7
Wholesale trade	13.1	18.1	21.2	24.3	28.0	32.0	36.5
Retail trade	58.6	72.5	84.7	99.3	113.0	132.0	155.0
Finance, insurance, and real estate	13.4	18.1	26.5	35.5	44.0	49.0	51.0
Business and repair services	8.4	9.7	11.4	14.0	16.7	20.0	24.0
Personal services	19.1	22.7	27.0	32.0	38.0	45.0	54.0
Entertainment and recreation	2.1	2.6	3.1	3.7	4.2	4.8	5.3
Professional services	52.2	69.4	86.5	112.4	138.0	172.0	216.0
Public administration	15.2	20.4	27.5	36.0	48.0	64.0	85.0
Industry not reported	10.9	12.4	16.8	22.0	24.2	29.0	35.0
Total, All Industries	392.0	473.9	549.5	648.6	747.2	864.1	998.3

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61-62, 85.

Battelle projections.

(a) U. S. Department of Agriculture, Economic Research Service, Resource Development Economics Division, East Lansing, Michigan. (See Part IV of this report for background data.)

(b) U. S. Bureau of Mines, Area III, Mineral Resource Office, Minneapolis, Minnesota. (See Part III of this report for background data.)

(c) Projections for 1980, 2000, and 2020 are from the U. S. Forest Service; projections for 1970, 1990, and 2010 are Battelle interpolations.

TABLE 59. INDEX OF PROJECTED EMPLOYMENT BY INDUSTRY IN THE AREA, 1960-2020

Industry	Per Cent of 1960 Employment						
	1960	1970	1980	1990	2000	2010	2020
Agriculture	100.0	96.6	84.2	80.8	79.3	74.4	71.4
Mining	100.0	87.5	87.5	100.0	112.5	137.5	162.5
Construction	100.0	115.7	135.3	159.3	186.3	221.1	254.9
Manufacturing	100.0	117.2	128.3	141.6	153.0	163.2	170.4
Durable manufacturing	100.0	117.7	127.6	140.1	149.7	156.8	160.3
Timber and wood products	100.0	112.5	118.8	150.0	181.3	225.0	262.5
Furniture and fixtures	100.0	120.7	116.3	114.1	110.9	108.7	106.5
Stone, clay, and glass	100.0	120.8	129.2	133.3	137.5	141.7	145.8
Primary metals	100.0	145.2	153.2	151.6	148.4	146.8	143.5
Fabricated metal products	100.0	106.2	103.1	105.0	105.0	105.0	106.2
Machinery, except electrical	100.0	95.2	108.0	109.6	112.8	113.9	117.6
Electrical machinery	100.0	214.9	268.9	323.0	371.6	408.1	433.8
Transportation equipment	100.0	103.9	112.4	115.2	116.3	118.9	118.9
Professional instruments	100.0	68.2	70.5	72.7	77.3	79.5	81.8
Other durable manufacturing	100.0	261.3	290.3	529.0	706.5	806.5	825.8
Nondurable manufacturing	100.0	115.2	131.2	147.6	166.2	188.8	210.3
Food and kindred products	100.0	106.7	111.2	118.0	123.6	130.3	137.1
Paper and allied products	100.0	109.1	109.1	118.2	127.3	136.4	145.5
Leather products	100.0	121.7	126.1	126.1	126.1	126.1	126.1
Printing and publishing	100.0	93.8	90.6	98.4	112.5	126.6	134.4
Rubber and plastic products	100.0	145.8	195.8	208.3	233.3	258.3	291.7
Other nondurable manufacturing	100.0	137.9	186.2	236.2	286.2	353.4	420.7
Transportation	100.0	109.0	121.3	134.4	149.2	165.5	186.1
Communications	100.0	93.8	102.1	110.4	125.0	141.7	164.6
Utilities	100.0	108.6	119.0	125.9	134.5	141.4	150.0
Wholesale trade	100.0	138.2	161.8	185.5	213.7	244.3	278.6
Retail trade	100.0	123.7	144.5	169.5	192.8	225.3	264.5
Finance, insurance, and real estate	100.0	135.1	197.8	264.9	328.4	365.7	380.6
Business and repair services	100.0	115.5	135.7	166.7	198.8	238.1	285.7
Personal services	100.0	118.8	141.4	167.5	199.0	235.6	282.7
Entertainment and recreation	100.0	123.8	147.6	176.2	200.0	228.6	252.4

TABLE 59. (Continued)

Industry	Per Cent of 1960 Employment						
	1960	1970	1980	1990	2000	2010	2020
Professional services	100.0	133.0	165.7	215.3	264.4	329.5	413.8
Public administration	100.0	134.2	180.9	236.8	315.8	421.1	559.2
Industry not reported	100.0	113.8	154.1	201.8	222.0	266.1	321.1
All Industries	100.0	120.4	140.2	165.5	190.6	220.4	254.7

Source: Derived from Table 58.

TABLE 60. PROJECTED PERCENTAGE DISTRIBUTION OF EMPLOYMENT BY INDUSTRY IN THE AREA, 1960-2020

(Total = All Industries = 100.0 Per Cent)

Industry	1960	1970	1980	1990	2000	2010	2020
Agriculture	5.2	4.2	3.1	2.5	2.2	1.8	1.5
Mining	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Construction	5.2	5.0	5.0	5.0	5.1	5.2	5.2
Manufacturing	34.4	33.5	31.4	29.4	27.6	25.4	23.0
Durable manufacturing	27.5	26.9	25.0	23.3	21.6	19.5	17.3
Timber and wood products	0.4	0.4	0.3	0.4	0.4	0.4	0.4
Furniture and fixtures	2.3	2.4	1.9	1.6	1.4	1.2	1.0
Stone, clay, and glass products	0.6	0.6	0.6	0.5	0.4	0.4	0.4
Primary metals	1.6	1.9	1.7	1.4	1.2	1.1	0.9
Fabricated metal products	4.1	3.6	3.0	2.6	2.3	1.9	1.7
Machinery, except electrical	4.8	3.8	3.7	3.2	2.8	2.4	2.2
Electrical machinery	1.9	3.4	3.6	3.7	3.7	3.5	3.2
Transportation equipment	9.9	8.5	7.9	6.9	6.0	5.3	4.6
Professional instruments	1.1	0.6	0.6	0.5	0.5	0.4	0.4
Other durable manufacturing	0.8	1.7	1.7	2.5	2.9	2.9	2.5
Nondurable manufacturing	6.9	6.6	6.4	6.1	6.0	5.9	5.7
Food and kindred products	2.3	2.0	1.8	1.6	1.5	1.4	1.2
Paper and allied products	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Leather products	0.6	0.6	0.5	0.4	0.4	0.3	0.3
Printing and publishing	1.6	1.3	1.1	1.0	1.0	0.9	0.9
Rubber and plastic products	0.6	0.7	0.9	0.8	0.7	0.7	0.7
Other nondurable manufacturing	1.5	1.7	1.9	2.1	2.2	2.4	2.4
Transportation	3.1	2.8	2.7	2.5	2.4	2.3	2.3
Communications	1.2	1.0	0.9	0.8	0.8	0.8	0.8
Utilities	1.5	1.3	1.3	1.1	1.0	0.9	0.9
Wholesale trade	3.3	3.8	3.9	3.8	3.8	3.7	3.7
Retail trade	15.0	15.4	15.4	15.3	15.1	15.3	15.5
Finance, insurance, and real estate	3.4	3.8	4.8	5.5	5.9	5.7	5.1
Business and repair services	2.1	2.1	2.1	2.2	2.2	2.3	2.4
Personal services	4.9	4.8	4.9	4.9	5.1	5.2	5.4

TABLE 60. (Continued)

Industry	1960	1970	1980	1990	2000	2010	2020
Entertainment and recreation	0.5	0.6	0.6	0.6	0.6	0.6	0.5
Professional services	13.3	14.7	15.7	17.3	18.5	19.9	21.6
Public administration	3.9	4.3	5.0	5.6	6.4	7.4	8.5
Industry not reported	2.8	2.6	3.1	3.4	3.2	3.4	3.5
Total, all industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Derived from Table 58.

Table 61 lists the projected mineral production for the Area.

TABLE 61. MINERAL PRODUCTION IN THE AREA, 1960 AND PROJECTIONS TO 2020

Product	Unit	1960	1970	1980	1990	2000	2010	2020
Clay	Thousand short tons	112	135	180	225	310	430	550
Gypsum	Ditto	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Limestone[b]	"	(a)	215	325	425	545	745	1,010
Marl	"	16	16	10	15	15	13	13
Peat	"	6	8	10	13	16	21	26
Sand and gravel	"	8,700	12,250	17,250	23,000	31,750	43,250	58,750
Natural gas	Thousand MCF	1,020	1,130	168	141	114	112	110
Petroleum	Thousand 42-gallon barrels	2,958	1,450	525	400	285	230	200

(a) Figure withheld to avoid disclosing individual company confidential data.
(b) Includes sandstone produced in Jackson subarea.

Source: U. S. Bureau of Mines
Area III Mineral Resource Office
Minneapolis, Minnesota
December 3, 1964

As the data in the table indicate, sand and gravel are projected to become the most significant minerals produced in the Area, while the presently significant petroleum and natural-gas production is expected to decrease sharply. Therefore, it has been assumed that changes in the levels of mining employment will be mainly functions of changing productivity (and projected production) in the sand and gravel industry.

Productivity in the sand and gravel industry has been projected by the U. S. Bureau of Mines to increase from a 1960 level of 9.75 tons per manhour to a 2020 level of 26.26 tons per manhour. Since projected output will grow faster than projected productivity, employment in the sand and gravel industry can be expected to increase in proportion to the net differences (see Table 62).

The 1960 Census of Population showed 750 mining employees in the Area, 535 of whom were accounted for (according to the Census', Detailed Characteristics for Michigan, 1960), by the three SMSA's, the Grand Rapids, Lansing, and Jackson subareas.

These workers were distributed within two groups:

Crude petroleum and natural gas[a]	250
Nonmetallic minerals	285
Total	535

(a) Includes eight employees listed under coal.

The 215 employees that were not accounted for in the detailed statistics were divided between these two groups on the basis of the ratio of the detailed data for the SMSA's, the 1960 production information, and the productivity information listed in Table 62. This results in the following estimate of mining employment in the Area:

Petroleum and natural gas	340
Nonmetallic minerals	410
Total	750

TABLE 62. SAND AND GRAVEL PRODUCTION, PRODUCTIVITY, AND NET PER CENT CHANGE IN SAND AND GRAVEL EMPLOYMENT, 1960 AND PROJECTIONS TO 2020

	Production		Productivity		Net Per Cent Change
Year	1000 Short Tons	Per Cent Change Over the Decade	Tons/Manhour	Per Cent Change Over the Decade	in Employment Over the Decade
1960	8,700		9.75		
1970	12,250	40.80	12.50	28.20	12.60
1980	17,250	40.81	15.25	22.00	18.81
1990	23,000	33.33	18.00	18.03	15.30
2000	31,750	38.04	20.76	15.33	22.71
2010	43,250	36.22	23.01	10.83	25.39
2020	58,750	35.72	26.26	14.12	21.60

Source: U. S. Bureau of Mines
Area III Mineral Resource Office
Minneapolis, Minnesota
December 3, 1964.

It was assumed that the proportionate changes in sand and gravel employment (Table 62) also apply to all other nonmetallic minerals workers, since sand and gravel employees seem to constitute a major portion of this category. Table 63 lists the decennial projections for employment in this group.

The projected decline in the production of petroleum and natural gas is expected to cause employment in this category to decline from its estimated 1960 level of 340 persons to a 2020 level of 100, assuming that no major petroleum discoveries will be made in the Area. Table 63 also reflects this projection.* As the projection indicates, it will not be until the 1980's that increasing employment in the nonmetallic category (principally the sand and gravel industry) is expected to offset declining employment in the petroleum and natural gas industry.

TABLE 63. TOTAL MINING EMPLOYMENT IN AREA, 1960 AND PROJECTED TO 2020

Year	Nonmetallic Minerals	Petroleum and Natural Gas	Total
1960	410	340	750
1970	462	275	737
1980	548	150	698
1990	632	156	788
2000	776	125	901
2010	973	125	1,098
2020	1,183	100	1,283

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan.

1970 to 2020: Battelle estimate.

The total estimated mining employment was divided among the subareas by assuming that each subregion would continue to account for the same proportion of the total that was reported in the 1960 Census. This is compatible with both the subarea projections of sand and gravel production (in which each subarea is expected to maintain approximately its 1960 share of total output) and projected petroleum and natural gas production, which is expected to decline in all presently producing subareas. (See Bureau of Mines Report in appendixes.) The resulting decennial projections for mining employment by subarea are shown in Table 64.

*Although employment by the major oil companies has been greatly cut back, it is expected that small, independent exploration will continue.

TABLE 64. EMPLOYMENT IN MINING IN THE SUBAREAS, 1960 AND PROJECTED TO 2020

Subarea	1960	1970	1980	1990	2000	2010	2020
Grand Rapids	347	341	327	362	417	508	594
West Central Belt	60	59	56	63	72	88	103
Lansing	126	124	117	131	152	184	216
Northeast Fringe	75	74	70	78	90	110	128
Jackson	142	139	134	148	170	208	242
Area	750	737	698	782	901	1098	1283

Source: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Table 65.

1970 to 2020: Battelle estimates.

Transportation. During the period from 1950 to 1960 employment in transportation in the Area decreased slightly from 12,617 to 12,205 employees. This was a result of countervailing trends in the transportation industry which saw the decline in railroad employment exceed the gains made by employment in trucking and warehousing. Table 65 gives a detailed view of the components of this change.

Projections of employment in transportation are based on discussions with officials of trucking companies, warehouses, railroads and airports in the Area. Also taken into consideration are the historical trends in the three transportation groups plus consideration of the current and near-future technological innovations that are greatly revolutionizing the entire transportation field.

The trucking industry employment in the Area increased at an annual rate of 2.5 per cent per year between 1950 and 1960. This is less than the growth experienced in 1940-1950, although the exact difference is uncertain due to the Census inclusion of "warehousing" with "trucking" for the first time in 1950. All signs tend to indicate that the prosperous growth of the trucking industry will continue throughout the United States and in the Area. The Grand Rapids subarea alone contains offices of 10 common motor carriers. The improved interstate highway system, the possibility of increased size and weight limitations for tractor trailers, and improved loading and warehousing methods are a few of the factors

TABLE 65. TRANSPORTATION EMPLOYMENT BY SUBCATEGORY IN THE SUBAREAS, AREA, MICHIGAN, AND UNITED STATES, 1940, 1950, AND 1960

Subarea	Railroad			Trucking and Warehousing			Other Transportation		
	1940	1950	1960	1940	1950	1960	1940	1950	1960
Grand Rapids	2,397	2,677	1,961	1,523	2,497	3,256	700	838	924
West Central Belt	257	269	185	184	283	357	65	117	128
Lansing	447	541	536	684	1,177	1,337	306	504	435
Northeast Fringe	1,041	985	609	207	331	615	96	150	144
Jackson	1,754	1,533	1,006	272	492	577	149	223	135
Area	5,896	6,005	4,297	2,870	4,780	6,142	1,316	1,832	1,766
Michigan	29,434	33,469	25,942	16,586	29,253	39,440	17,161	26,477	21,296
United States	1,135,019	1,385,684	941,214	427,626	700,682	911,454	615,029	854,297	887,245

Source: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

expected to lead to greater volume and employment in the trucking industry. The employment in trucking and warehousing is projected to increase, at the somewhat lower annual rate of 2 per cent per year between 1960 and 1980, and at a rate of 1.4 per cent per year thereafter. This increase promises to outweight the short-term decline in railroad employment and will lead to increased employment in the over-all transportation category.

Railroad employment during the 1950-1960 decade decreased at an annual rate of about 3.3 per cent in the Area. The rate of decline was 2.5 per cent per year in Michigan and 3.8 per cent per year in the U. S. Many uncertain factors cloud the employment future of this industry: possible railroad mergers, changes in crew size, yard automation, increased "piggy back" activity, and increased use of trilevel railroad cars for auto transport have implications for future employment levels in the Area. New developments in interurban high-speed rail passenger transportation could also effect rail employment.

The future employment outlook was discussed with several officials of railroads serving the Area. As a result, the decline in railroad employment is projected to continue through 1980 at a somewhat lower rate than that of the 1950's. A modest increase in employment is expected during the remainder of the projection period.

In 1960, about 14 per cent of the Area's transportation employees were employed in the category "Other Transportation". Most of these are in the bus, taxi, or air transportation field. This group is projected to increase moderately and constitute about 12 per cent of the 2020 total. Table 66 lists the projected employment for the various transportation categories.

TABLE 66. TRANSPORTATION EMPLOYMENT BY SUBCATEGORY IN AREA, 1960 AND PROJECTED TO 2020

Year	Railroad	Trucking and Warehousing	Other Transportation	Total
1960	4,297	6,142	1,766	12,205
1970	4,000	7,400	1,900	13,300
1980	3,800	9,000	2,000	14,800
1990	3,900	10,300	2,180	16,380
2000	4,000	11,900	2,300	18,200
2010	4,180	13,500	2,500	20,180
2020	4,400	15,600	2,660	22,660

Source: 1960, U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Table 85.

1970-2020: Battelle projections.

Communications. The communications industry is primarily composed of telephone, telegraph, and radio and television broadcast workers. Eighty-seven per cent of the workers are in telephone and telegraph.

The monopolistic nature of the industry means that there are relatively few companies in any of the subareas and, because of the Bureau of the Census disclosure regulations, official data are quite fragmentary and incomplete.

To get around this problem the numbers of communications workers in the U. S. and Michigan have been related to population in Table 67 and Figure 13. In the past, the U. S. has required more communication workers per 1000 population than has the state of Michigan. This relationship was corroborated by field interviews. It reflects the fact that the technological sophistication of capital in the communications industry varies regionally throughout the U. S., with the more industrially developed states having the newer equipment.

This technological differential between Michigan and the U. S. is expected to narrow as the telephone industry completes its conversion to electronic and solid-state equipment. This is reflected in Figure 13 and Table 67 by the Battelle projections for the years 1970 to 2020.

TABLE 67. COMMUNICATIONS EMPLOYMENT AND POPULATION, UNITED STATES, MICHIGAN, AND AREA, 1951-2020

Year	U. S. Population[a], thousands	Communications Workers in the U. S.[b]	U. S. Communications Workers Per 1000 U. S. Population	Michigan Population[a], thousands	Communications Workers in Michigan[b]	Michigan Communications Workers Per 1000 Michigan Population	Ratio of Area Population to Michigan Population	Communication Workers in Area
1951	154,060	676,389	4.39	6,489	28,191	4.344		
1953	159,035	--	--	6,803	30,822	4.531		
1956	166,019	779,316	4.694	7,426	34,067	4.588		
1959	177,131	832,584	4.70	7,753	31,773	4.098		
1960	179,323	819,600	4.51	7,823	32,032	4.09		4,784
1962	185,890	814,941	4.384	7,923	30,597	3.862		
1970	208,996	773,285	3.7	8,954	31,339	3.5	0.14205	4,452
1980	245,313	834,064	3.4	10,413	33,842	3.25	0.144608	4,894
1990	288,219	922,301	3.2	12,177	37,749	3.1	0.13898	5,246
2000	338,219	1,055,243	3.12	14,238	43,425	3.05	0.13826	6,004
2010	399,256	1,213,738	3.04	16,593	49,779	3.0	0.13723	6,831
2020	470,442	1,411,326	3.00	19,103	57,309	3.0	0.13779	7,897

Sources: (a) 1951-1962 - U. S. Bureau of the Census Estimates; 1970-2010 - U. S. Bureau of the Census Series B Projections; 2020 - Battelle estimate.
(b) 1951-1962 - U. S. Bureau of the Census, County Business Patterns; 1970-2020 - Battelle estimates.

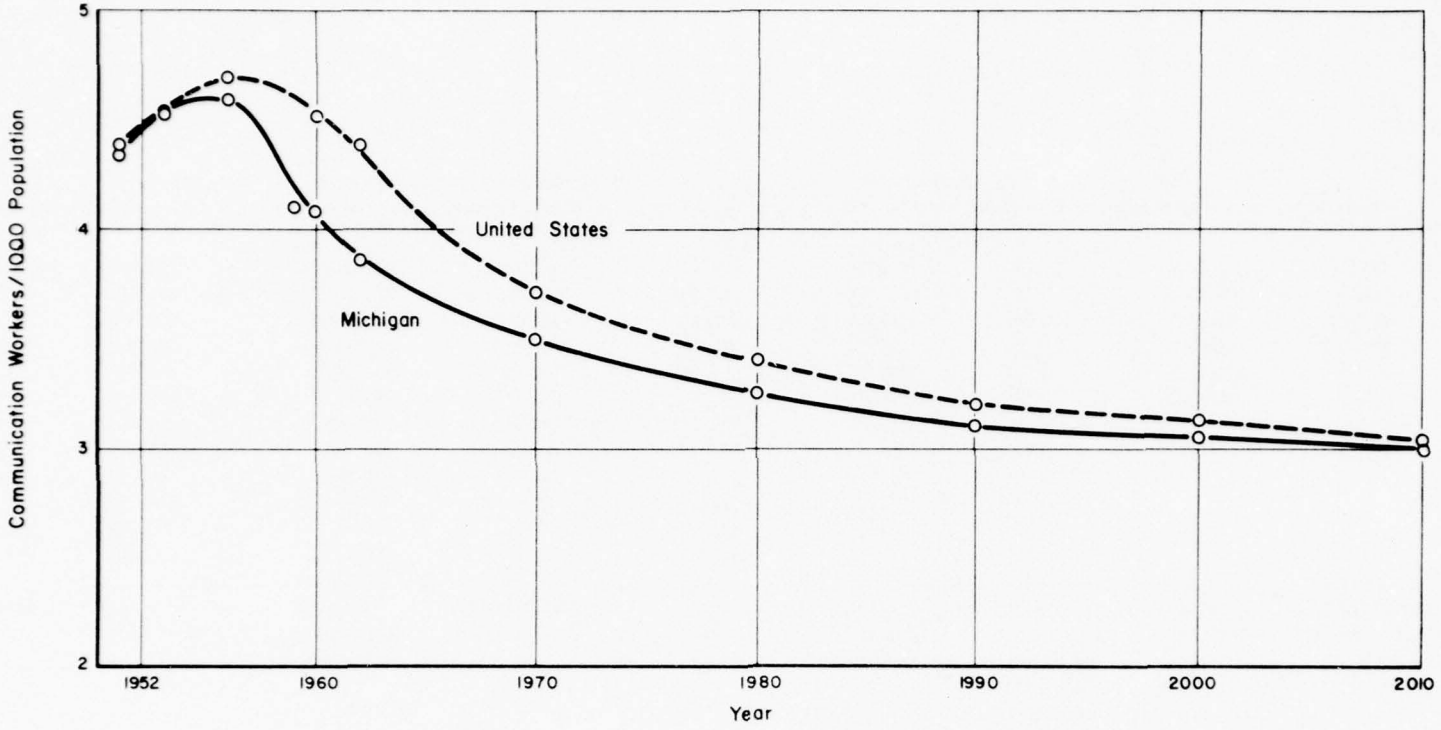

FIGURE 13. RATIO OF COMMUNICATIONS WORKERS TO POPULATION FOR THE UNITED STATES AND MICHIGAN

Source: Table 67.

Multiplying the projected ratio (communications workers/ population) by projected population estimates yields projected employment in communications for the years 1970 to 2020 for both the U. S. and Michigan. These figures are given in Table 67. Total employment is predicted to decline slightly through 1970 and then begin to grow. This rate of growth for the 1970-2020 time period is 1.2 per cent for the U. S. and for Michigan. Field interviews also indicate that employment in the telephone industry as a whole would still continue to decline slightly in the near future, but the Bell System expects this trend to reverse soon, so employment is expected to grow at about 1 to 1-1/2 per cent annually.

Employment in the Area and its subareas is projected by assuming that employment will be proportional to population. As noted above, this assumption was necessitated by the lack of data at these levels of dissegregation. The results of these calculations are given in Table 81.

Utilities. The utilities category is defined by the U. S. Census to include employees in five subcategories: electric light and power, and electric-gas utilities; gas and steam supply systems; water supply; sanitary services; other and not specified utilities. Of the 5753 employees reported in the Area in 1960, over 80 per cent (4601 employees) were in the three SMSA's of the subareas (Grand Rapids, Lansing, and Jackson). In this group, approximately 70 per cent of total employment was in the electric and electric-gas utilities.

Consumers Power Company, with headquarters in Jackson, is the major employer in the electric utility group. The company serves most of the Area, maintaining large staffs in Lansing, Grand Rapids, and Owosso. In addition, there are several municipal electric companies in the Area, the largest of which serves the city of Lansing.

Employment projections for this category take into account: (1) a historical analysis of utility-employment data, (2) field interviews with public and private utility officials, and (3) recognition of the technological trends occurring in the utility industry. Table 68 shows historical employment by subareas. As can be seen from the table, employment in the Area changed from a 2.2 per cent per year rate of increase in 1940-1950 to an annual rate

of 1.4 per cent in 1950-1960. The comparable State rates dropped from 3.8 per cent to 0.4 per cent per year.

TABLE 68. EMPLOYMENT IN UTILITIES IN THE SUBAREAS, AREA, MICHIGAN, AND UNITED STATES, 1940, 1950, AND 1960

Subarea	1940 Number	1940 Per Cent of Area	1950 Number	1950 Per Cent of Area	1960 Number	1960 Per Cent of Area
Grand Rapids	1,338	33.4	1,650	32.7	1,593	27.7
West Central Belt	240	6.0	368	7.3	413	7.2
Lansing	870	21.7	1,110	22.0	1,353	23.5
Northeast Fringe	355	8.9	406	8.0	392	6.8
Jackson	1,202	30.0	1,510	29.9	2,002	34.8
Area	4,005	100.0	5,044	100.0	5,753	100.0
Michigan	24,287		35,278		36,878	
United States	542,382		781,907		898,585	

Note: Detail may not add to totals due to rounding.

Sources: U. S. Census of Population: 1940, Characteristics of the Population, Michigan, Tables 18 and 23.
U. S. Census of Population: 1950, General Characteristics, Michigan, Tables 30 and 43.
U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61 and 85; General Social and Economic Characteristics, United States Summary, Table 92.

Consumers Power, the major utility employer in the Area, used to be primarily a construction company and is now primarily a service and maintenance company. Modern equipment has enabled the company to reduce the size of its work crews. Increased mechanization and automatic data processing have also led to the decreasing rate of employment growth. Although the Area's electrical-energy requirements increased by almost 350 per cent during 1940-1960, employment increased by less than 50 per cent.

Information concerning the future employment outlook was gathered in interviews with officials at Consumers Power Company, the Lansing Board of Water and Light, and the water and sanitary departments in Jackson, Lansing, and Grand Rapids. The information from the interviews combined with an evaluation of the historical trend led to projecting a modest increase in the Area's employment, as seen in Table 69. During the projection period, the rate of growth experienced in the Area is expected to approach

that experienced by the state of Michigan in the 1950-1960 period. The projections therefore assume a 0.9 per cent annual growth rate during 1960-1980 and a 0.6 per cent rate during 1980-2020.

TABLE 69. EMPLOYMENT IN THE UTILITIES IN THE AREA, 1960 AND PROJECTIONS FOR 1970-2020

1960	5753
1970	6292
1980	6882
1990	7307
2000	7758
2010	8237
2020	8744

Source: 1960: U. S. Census of Population: General *Social and Economic Characteristics*, Michigan.
1970 to 2020: Battelle projection.

Contract Construction. The industries of contract construction; wholesale and retail trade; finance, insurance, and real estate; business and repair, and personal services are projected on the basis of similar factors. They are projected on the assumption that their growth will be determined primarily by future population and employment growth (in other industries) and by growth in general business activity. In 1960, there were approximately 20,000 employed in contract construction in the Area, constituting about 5.2 per cent of total employment in the Area (see Table 60). Some small decline in the relative share of employment in contract construction during the 1960's and 1970's is likely as new construction techniques and materials lead to a decline in labor inputs required to maintain a given level of construction activity. It is anticipated that technological developments in the construction industries will include advances into larger and more powerful equipment, improvement in materials and materials handling, prefabrication of building components, and changes in architectural design.

Today, earth moving machines allow essentially the same amount of operating labor to move many times the amount of material that could be moved a few years ago. Automatic controls have become more widespread, and improvements in such component parts as transmissions has increased machine productivity greatly. The use of tower cranes is solving many material-handling problems associated with the construction of very tall buildings, and the use of other specialized machinery (such as plastering machines) is reducing labor requirements. On large projects, computer scheduling of operations improves the allocation of labor, equipment, and materials. The trends to off-site manufacturing of building components, to greater mechanization of building-materials handling equipment, and to lessened responsiveness to day-to-day weather conditions, all tend to reduce labor requirements.

On the other hand, the level of demand for business and residential construction will rise because of increases in population, replacement demand for new and better houses, and trends of growth in national output and employment. Employment in public construction will also increase rapidly because of expanding needs for schools, highways, urban renewal programs, hospitals, sewer and water systems, and other socially provided services.

Considering these counter trends, some small decline in the share of total employment accounted for by contract construction can be projected during the 1970's and 1980's. Thereafter, construction employment will tend to grow slightly relative to total employment. By 2020, it is projected that construction employment in the Area will constitute 5.2 per cent of total employment, approximately the same proportion as in 1960.

Wholesale and Retail Trade. In 1960, wholesale and retail trade together employed nearly 70,000 people - slightly more than 18 per cent of the Area's total employment. Nearly 59,000 persons were employed in retail trade.

Wholesale-trade employment may be classified in four broad categories: assemblers, buyers, and those engaging similar

activities; brokers, agents, and commission merchants; sales and other branch offices maintained by manufacturing concerns; and merchant wholesalers.

As indicated above, employment in wholesale trade constituted less than one-fifth of total employment in trade in 1960. This proportion remained remarkedly stable over the last several decades and is expected to continue to do so in the future. However, wholesale trade is subject to more technological innovation than retail trade.

For instance, efficiency in wholesale trade is expected to grow through the use of automatic equipment for wrapping, sorting, and moving goods, through fuller use of conveyerized materials handling systems, through use of data-processing equipment in inventory control, and through central prepacking of perishable foods and possible advances in food processing techniques that could reduce the refrigeration requirements. Moreover, a large part of the increased employment in this industry is expected to be met by part-time workers, including women and younger workers.

In light of the anticipated increased demand for all services, including wholesale and retail trade, it is projected that wholesale trade will account for 3.8 per cent of total employment in the Area in 1970 and for 3.9 per cent in 1980. Subsequently, increased productivity should arrest this relative growth. By 2020, it is projected that wholesale trade will account for 3.7 per cent of the Area's total employment.

Historically, retail trade has experienced relatively insignificant increases in productivity. There are many technological changes which will have an impact on employment in retail trade in the future. These include automatic checkout counters, more use of vending machines, expansion of electronic data processing, improved accounting methods, control operations, and possible use of point-of-sale recorders which collect details of transactions on register tapes for optical scanning as computer inputs. Nevertheless, there is little reason to believe that these productivity increases will offset the anticipated increased demand for employment in retail trade resulting from growing consumer demand derived from increased income. Therefore, retail trade has been projected as accounting for a slightly larger percentage of total employment in the Area during the projection period. In 1960, retail trade provided 14.9 per cent of the Area's employment.

By 1970, it is projected to provide 15.4 per cent, and by 2020, 15.5 per cent. In other words, employment in retail trade is expected to grow from approximately 59,000 in 1960 to 155,000 by the year 2020.

Finance, Insurance, and Real Estate. In 1960, approximately 13.4 thousand people in the Area were employed in the finance, insurance, and real estate industry. Thus, this industry accounted for 3.4 per cent of total employment in the Area.

In banking, greater use of computers and magnetic-ink character recognition, automation, electronic bookkeeping machines, machines to receipt deposits, and closed-circuit TV combined with the pneumatic tubes and other advances will lead to faster customer service and improved efficiency. Extension of electronic data processing, automatic reading devices, data-transmission systems, and a host of marketing innovations, including sales of packaged policies by insurance companies and direct selling, are among recent sources of higher productivity in this industry. Demand for the services which this industry provides is expected to grow in proportion to rapidly expanding incomes and the substantial growth anticipated in the number of professional and technical workers. While employment is expected to grow, it will be at a lower rate than in recent postwar years because of technological changes.

Consequently, the service industry is projected to account for approximately 3.8 per cent of total employment in 1970 and to grow to the point where it accounts for over 5 per cent of employment in 2020. In other words, by 2020 there will be over 50,000 people employed in the Area in finance, insurance, and real estate, an almost four-fold increase over employment in 1960.

Business and Repair Services. Business and repair services cover a variety of activities, including advertising, duplicating, addressing, blueprinting, photocopying, window cleaning, news syndication, private employment agencies, research, development and testing laboratories, management and consulting services, automobile repair services and garages, and other miscellaneous repair services. This conglomerate industry provided employment for approximately 8.5 thousand workers (about 2 per cent) in the Area in 1960.

Growth of this industry is enhanced by the growth of manufacturing and other nonlocal industries who contract out their specialized service needs. On the other hand, many business services such as printing and duplication are experiencing rapid increases in labor productivity. Some repair services are likely to constitute a decreasing source of jobs in the future as more and more components are replaced rather than repaired in future machines.

Because of this admixture of forces, business and repair services are projected to grow at approximately the same rate as total employment between 1960 and 1980. Thereafter, however, it is anticipated that the growth of manufacturing industries will lead to some relative growth in business and repair services as a source of employment. As a result, by 2020, it is projected that these industries will account for 2.4 per cent of total employment in the Area and employ approximately 24,000 people.

Personal Services. Personal services include such activities as private household workers, hotels, laundering, cleaning and dyeing services, dressmaking shops, shoe repair shops, barber shops, and beauty shops.

In 1960, over 19,000 people in the Area were employed in the personal-services industry. This industry accounted for nearly 4.9 per cent of total employment in the Area in that year. Employment in this industry is expected to increase in the future in proportion to total employment as increases in per capita income and growth of younger age groups lead to a relative expansion in the demand for those providing personal services. It is not anticipated that major technological change will affect the demand for labor in this industry. Therefore, it is projected that the personal services' share of total employment in the Area will rise during the projection period. It is estimated that by 2020 this industry will employ approximately 54,000 persons and account for 5.4 per cent of total employment in the Area.

Entertainment and Recreation. A multitude of service activities are included in entertainment and recreation, including the motion-picture industry, bowling halls, pool parlors, yacht clubs, golf courses, and city playgrounds. The trend toward increasing amounts of leisure time, income, and education has led to a growing demand for all types of recreational activities. States and regions have been actively competing for increased shares of the growing recreational expenditures. As a result, numerous studies have been and still are being conducted to assess national and regional recreational needs and to determine local recreation potential.

Increased demand for entertainment and recreational activities is easily documented by various statistics from increased movie attendance to overcrowded park facilities. Although these increases in user demand cannot be converted directly to increases in employment, it is safe to conclude that employment in the entertainment and recreational field will increase substantially during the projection period.

Historical data indicate that Area employment in this category increased slightly during 1940-1960 (1950 data were inflated by the inclusion of radio and TV broadcasters and cannot be used). It is expected that employment in this category will continue to maintain its 1960 share of Area employment (about 0.5 per cent) during the projection period. As a result, the numbers of persons employed in this industry are projected to increase at an annual rate of approximately 1.5 per cent throughout the projection period.

Professional Services. Although this report does not attempt to detail the precise nature of the changes which will be occuring in the structure of the economy during the sixty years from 1960 to 2020, many of these changes are evident in the statistics presented. For example, labor force participation is expected to decline, even after the effects of shortening the work week are taken into account. Likewise, the projections for employment in professional services (and for public administration, discussed in the next section) should be discussed somewhat more fully to point out the social and economic changes which are expected to result in the patterns shown.

From Table 59 it is evident that employment in the Area's professional services will expand by more than 65 per cent

between 1960 and 1980 and by 2020 will reach a level more than four times its 1960 level. Only public administration is expected to grow faster. This growth can be explained in terms of the types of employment associated with professional and related services. This category includes such activities as medical and other health services, legal services, education, welfare and religious services; and engineering, architectural, accounting, and bookkeeping services. These activities will grow rapidly in employment for three fundamental reasons:

(1) Historically, when discretionary income has risen, outlays on these professional services have gone up proportionately. By 1980, according to the projections contained in this report, national income per capita will have increased to a level of $3,670, nearly 60 per cent over the 1960 level. By 2020, this measure will exceed $8,500. This implies that the demand for professional and related services will rise even more rapidly.

(2) The emergence of a human-resources-oriented economy will stimulate expansion of educational services. As mentioned earlier, individuals will participate increasingly in education. This will apply to adults as well as to the younger age groups. While it is anticipated that teaching innovations can be made which will increase the number of students served by a single teacher, in many instances the expansion of specialization and the growth of advanced-degree work will have an offsetting influence, leading necessarily to lower student/teacher ratios.

(3) Employment in professional and related services is in large measure a personal service offered by a professionally trained individual. As a result, it is unlikely that productivity in this sector will rise significantly. In other words, growing demand will be translated into relatively more employment in these activities. Hence by 1980, professional and related services in the Area are expected to account for 15.7 per cent of all employment, compared with 13.3 per cent in 1960 and a projected level of 21.6 per cent in 2020.

As patterns of living change to serve the needs of a more sophisticated and demanding public, regional economies throughout the Nation will shift along lines indicated by these projections for the Area. One measure of a region's comparative advantage will be the level of professional and related services available to it. The generally favorable prospects for the Area which are implicit in this report rest upon a judgment that, in general, the Area will succeed in attracting and developing these services. Hence, these relative shifts in employment from manufacturing to services are particularly crucial to the projected development of the Area.

Public Administration. Closely related to the provision of professional and technical services is the public administration sector. This kind of employment is defined as largely administrative, since the operating segments have been included in other employment categories. For example, the State administrative offices for education are included in public administration, but the major portion of employment provided by the public schools (i. e. , teachers) will be included with the professional and related services.

The growth projected here for public administration is large in relative terms (see Table 59). By 1980 this type of employment will be 80 per cent larger than in 1960 and by 2020 it will be over five times its 1960 size. The number of employees in the Area's public administration will grow from 15,200 in 1960 to 27,500 in 1980, to 85,000 in 2020. However, when the different activities which the various levels of government will be expected to administer are considered, this growth does not appear so dramatic.

In the mid-1960's, economists and social observers generally agree that the wave of young people currently seeking entry into the labor force and our institutions of higher education have an impact which is bringing into focus a number of major problems that call for expanded public programs. When these problems are added to the difficulties associated with retraining the displaced workers over 40 years old and with the expanding retired population, it is evident that employment in public administration must expand. This statement can be made with confidence, since major new programs have already been legislated and others are currently in the legislative hearing rooms.

This division of employment includes federal, state, and local governments, so it is not necessary to evaluate the alternatives for developing these services. Even when federal funds are involved, the concern in these projections is the employment which will be found within the Area and the subareas. During the 1950-1960 decade, employment in public administration increased at an annual rate of 2.5 per cent. Growth to the projected 1980 level of 27.5 thousand workers implies an annual growth rate of 3.0 per cent. This higher growth rate is certainly justified by the anticipated expansion of programs. In 1960 there were 72 persons to be served by each public-administration employee. By 1980 this ratio will be reduced to 54.8, a decline of 23 per cent. The projected employment in 2020 represents a further decline of 43 per cent in the ratio during the four decades from 1980 to 2020.

These projections reflect both our recognition of a continuing demand for public services and our evaluation of the degree to which technological change will affect public administration. While productivity is difficult to measure in activities which do not provide a tangible output* (and where quality is especially important), it would appear that many of the services found within public administration will not be subject to radical innovations affecting productivity. A variety of administrative labor saving devices have emerged including computers, microfilm, copy equipment, and data transmission and communications and materials-handling devices. These advances increase efficiency and reduce employment in certain clerical tasks, in routine jobs, and in other similar activities. For example, in 1963, the Federal government had 1,248 electronic computers. These developments undoubtedly create many new, highly skilled jobs while eliminating unskilled or semiskilled employment opportunities. In the Federal Government, for example, electronic computers are being used in accounting, check disbursing, insurance payments, tax-return processing, and inventory control. Certain Federal agencies are looking into the possibility of using optical-character-recognition (OCR) equipment for automatically reading and transcribing original text onto cards, paper, or magnetic tape, or even directly into computers. Any of these applications can feed input data into computers and thus eliminate manual transcription by keypunch operators.

*See Bureau of the Budget, Measuring Productivity of Federal Government Organizations, U.S. Government Printing Office, Washington, D.C. (1964), p 6.

The impact of these technological developments on local and state governments depends on the size and absorptive capacity of these agencies and the nature of the functions performed. These projections are based on a modest use of such innovations in virtually all areas of public administration.

Manufacturing. In 1960, there were nearly 165,000 people in the Area employed in various manufacturing industries. Manufacturing accounted for 35.1 per cent of total employment. In recent years, manufacturing as a proportion of total employment in the nation has been declining. It is anticipated that this relative decline will continue into the future. The decline, reflecting increased productivity, has permitted expanded output with less labor input and has increased levels of income. This in turn has led to a relative shift in consumer demand from manufactured goods to services. These trends will also be felt in the Area, where manufacturing employment will increase but not as rapidly as total employment.

By 1980, it is projected that nearly 173 thousand people will be employed in the Area's manufacturing industries and, by 2020, nearly 230 thousand. As a result, manufacturing will account for 31.4 per cent of employment in 1980 and only 23.0 per cent in 2020.

The total employment projected for manufacturing is principally determined by projected employment in motor vehicles and related industries, although it is also affected by other key industries in the area. The projection for each of these industries is considered separately in the following section.

SECTION F. GRAND RIVER BASIN: DETAILED EMPLOYMENT PROJECTIONS FOR THE AREA'S MANUFACTURING INDUSTRY (1960-2020)

In order to project the general economic structure of the Area, as presented in the preceding sections, it has been necessary to investigate a number of specific manufacturing industries. The following sections present analyses for furniture; stone, clay and glass products; primary metals; fabricated metal products; machinery (except electrical machinery); electrical machinery (with special reference to household appliances); transportation equipment; professional, scientific, and controlling instruments; food and kindred products; leather products; printing and publishing; and rubber and plastic products.

These detailed studies involved field interviews, both inside and outside the Area, wherever industry experts could provide information. Furthermore, these studies have involved careful analyses both of historic trends and of the general regional structural changes expected to occur throughout the nation. The projections for the over-all economic structure of the Area were developed with these data as the base.

I-25. Furniture

Furniture manufacture is an important source of Area employment, particularly in the Grand Rapids subarea. Since 1960, employment in this industry has declined because several plants closed. Decreases in demand have been especially severe for the manufacturers of household furniture.

In 1960 approximately 9,000 people in the Area were employed in furniture manufacturing; 5.2 thousand were in the manufacture of household furniture and 3.2 thousand in the manufacture of office and public-building furniture.

A recent study* projects the value of shipments of household furniture in 2000 as 190 per cent of its 1962 level, with a corresponding 240 per cent growth in the value of shipments of

*U. S. Department of Agriculture, Forest Service, "Timber Trends in the United States", Forest Resource Report No. 17.

commercial and institutional furniture over the projection period. However, historical trends suggest that the Area's furniture industry may not share in this projected growth. Between 1948 and 1962 the value of shipments of household furniture in the Nation nearly doubled, as did the value of commercial and institutional furniture.* Employment in the furniture (and lumber and wood) industry of Michigan (most of which is located in the Area) actually declined from 12.8 thousand to 11.2 thousand between 1950 and 1960.

It is anticipated that between 1960 and 1980 employment in the manufacture of household furniture in the Area will decline. Some of this decline has already occurred. Further, it is anticipated that the locational shifts occurring in this industry (principally to the Southern States and to California) will continue, to the disadvantage of household-furniture manufacture in the Area. As a result, employment in household furniture is projected to decline from 5.2 thousand in 1960 to 4.5 thousand by 1980.

During this same period, however, Area employment will increase in the manufacture of office furniture and public-building furniture. The Area's competitive disadvantage in the manufacture of furniture of this type is much less than in the manufacture of household furniture. As a result, it is anticipated that total employment in these two sectors of the furniture industry will increase from 3.2 thousand in 1960 to 5.7 thousand by 1970 and then level off. After 1980, as incomes continue to rise and consumer tastes focus more on quality at higher prices, the manufacture of household furniture may recover in the Area. In all likelihood, total employment in the furniture industry will not grow appreciably during this period, but the manufacture of household furniture may replace the manufacture of office and public-building furniture as the expanding segment of the industry.

As a result of these mixed trends, employment in furniture manufacture in the Area is expected to grow to 11.1 thousand in 1970 and then to decline slowly to 9.8 thousand by 2020.

I-26. Stone, Clay, and Glass Products

The stone, clay, and glass products manufacturing industry accounted for only 2.4 thousand jobs in the area in 1960 (including

*U. S. Department of Agriculture, Forest Service, "Timber Trends in the United States", Forest Resource Report No. 17.

700 in the manufacture of abrasive products) and it is projected to experience mild growth over the projection period. It is anticipated that employment in this industry will reach 3.5 thousand by 2020 and that employment in abrasive products will rise from 700 to approximately 1500 by that same year.

I-27. Primary Metals

In 1960, the primary-metals industry accounted for 6.2 thousand Area jobs, 2,000 in iron and steel forgings and 4,200 in other primary-metals industries. Employment trends in this industry are closely related to employment trends in the motor vehicles and motor vehicles equipment industry. The anticipated trends in the latter have therefore been applied to the primary-metals industry for purposes of projection. As a result, employment in primary metals is projected to increase from 6.2 thousand in 1960 to 9.0 thousand in 1970 and to 9.5 thousand by 1980. Thereafter, gradual declines are anticipated, until by 2020 this industry will be the source of 8.9 thousand jobs. No similar pattern is anticipated for iron and steel forgings, since that industry is not totally dependent on motor vehicles and equipment. Consequently, it is anticipated that employment in iron and steel forgings will increase gradually from 2,000 in 1960 to 3,000 in 2020.

I-28. Fabricated Metal Products

For purposes of this analysis, the fabricated-metal-products industry is considered to consist of three subindustries: cutlery, hand tools, and general hardware; metal stampings; and other fabricated metals (a residual industry). The major industry group, fabricated metal products, employed just over 16,000 people in the Area in 1960. It is projected that employment in this group will rise somewhat between 1960 and 1980 and then generally level off so that by 2020 there will be approximately 17,000 employed in the industry. Analysis of national data indicate that employment in this industry has been generally stable in recent years, and we project it to remain so. The Area projections reflect the assumption that, taken as a whole, this industry's employment behavior in the Area will not seriously deviate from that in the nation.

Cutlery, hand tools, and general hardware was the source of 4,000 Area jobs in 1960. Employment in this subindustry is projected to follow the major group's trend throughout the projection period. As a result, it is anticipated that employment may increase somewhat between 1960 and 1970, decline slightly to 1980, and then level off. It will show some slight rise over the entire period 1960-2020.

The metal-stampings industry in the Area employed 4.8 thousand workers in 1960. This industry is closely tied to prosperity in the motor-vehicles industry; and employment in metal stampings is considered to be closely related to employment in motor-vehicles manufacture. Consequently, the projected employment for metal stampings parallels that projected for motor vehicles in the Area and in the state. Employment is projected to increase from 4.8 thousand in 1960 to approximately 7.5 thousand by 2020.

I-29. Machinery, Except Electrical Machinery

This industry was a major source of employment in the Area in 1960, when it employed 18.7 thousand workers. The industry, for purposes of this analysis, is made up of two subgroups, and a third industry is included in one of the subgroups. These are metalworking machinery and its subindustry, special dies and tools, and other nonelectrical machinery, a residual conglomerate.

The primary determinant of employment in the metalworking-machinery subindustry in the Area is employment in special dies and tools. Employment in this industry, as in the case of many others in the Area, is related to demands of the automobile industry. Consequently, special tools and dies is projected on the basis of projected employment in motor vehicles and equipment, after allowance for probable differential productivity trends between the two industries. The residual (other than special dies and tools) in metalworking machinery is projected to grow slightly over the projection period, with the result that employment in this industry is projected to increase from 6.5 thousand in the Area in 1960 to 11.8 thousand by 2020. The projection of a major industry group, all machinery except electrical machinery, reflects the projection for metalworking machinery and the projection for the residual "other nonelectrical machinery" industry. This residual

industry employed 12.2 thousand in 1960. It is anticipated that the industry will experience an erratic long-term decline as a source of employment, falling from 12.2 thousand in 1960 to 10.2 thousand by 2020. This decline reflects the assumption that increases in productivity, as well as the relative decline in consumer demand for manufactured goods (the manufacture of which constitutes the market for nonelectrical machinery), will result in slight declines in this industry as a source of employment.

I-30. Electrical Machinery

This major group includes establishments engaged in manufacturing machinery, apparatus, and supplies for the generation, storage, transmission, transformation, and utilization of electrical energy. The manufacture of household appliances is also included in this group.

Household Appliances

The household-appliances industry, is one of the major industries in the Area. Therefore, it has been analyzed separately.

Recent demand for appliances has followed its own cycle. Table 70 shows the retail sales volume for the major appliances (home laundry equipment, dishwashers, refrigerators, freezers, and ranges). It is observable that their sales are not simply correlated with some single variable such as disposable income. General Electric has recently completed a very extensive study of future appliance demand.* This study forms an integral part of our analysis and projection. Its method of forecasting is based on the study of a sample of 10,000 households. A variation of discrimination analysis was used, and household or market segments were constructed. The total household sample was broken down into 128 market segments, each with seven characteristics. This process enabled General Electric to identify the social, economic, and demographic factors associated with high and low purchase rates. These factors were assumed to remain stable

*Francis P. Murphy, New Perspectives of Appliance Forecasting, a speech given at the Sixth Annual Forecasting Conference, April 17, 1964.

TABLE 70. RETAIL SALES OF MAJOR APPLIANCES IN CONSTANT DOLLARS, UNITED STATES

(Constant 1957-1959 Dollars)

Year	Sales, millions dollars
1954	3,067
1955	3,729.4
1956	3,929
1957	3,548.8
1958	3,468.8
1959	3,996
1960	3,610
1961	3,539.7
1962	3,811
1963	4,252

Source: Electrical Merchandising Week, 1964, Statistical and Marketing Section, pp 68-69. Wholesale Price Indexes, Statistical Abstract of the U. S. (1964), p 353.

TABLE 71. MAJOR-APPLIANCE PRODUCTION INDEX: U. S. (PROJECTED)

Year	Index
1963	100.0
1964	104.0
1965	111.0
1966	115.3
1967	119.0
1968	122.2
1969	125.4
1970	128.9
1971	133.9
1972	137.7
1973	142.0

Source: General Electric Co., Economic Research Department, New York City (1964).

over time, and projections were made taking into account the secular changes in the economy.

The final result of General Electric's calculations is shown in Table 71. Note that they did not project beyond 1973. To obtain projections to 1980, an ordinary least-squares trend line was computed. Its equation is

$$\text{Index} = 91.32 + 4.294\ T,$$

where T is the coded value for the year under consideration – 1962 = 1, 1963 = 2, etc. The final estimated production index for household appliances is shown in Table 71. It is assumed that value added would be proportional to projected output. The value added in household appliances in 1963 was $2,052 million.* To arrive at national employment figures it is necessary to project value added per employee. This is complicated by the fact that technological change has occurred at a very rapid pace in household appliances. From 1958 to 1963 productivity rose at an annual rate of 7.3 per cent per year. It is not expected that the trend will continue at this very high rate. Therefore, the following growth rates of productivity are assumed:

1963-1965	6 per cent
1965-1970	4 per cent
1970-1975	3.5 per cent
1975-1980	3 per cent

Next, the total number of workers in the household appliance industry is calculated by dividing value added by value added per worker. These estimates are shown in Table 80. Finally, based on Michigan's and the Area's share of national output and employment in 1962, future employment and output are projected assuming that these regions retain their present share.

Projections for employment in household appliances after 1980 are made on the basis of the assumption that a combination of increased productivity as well as growth in that segment of the industry located outside the Area would result in relatively stable levels of Area employment. Specifically, employment is projected to increase from about 4,000 workers in 1960 to over 5,000 in 1970 and 1980, reaching a peak of 5,500 in 1970. Thereafter, slight declines are projected so that employment in 2020 in this industry in the Area is projected to be 5.0 thousand.

*U. S. Department of Commerce, Bureau of the Census, 1963 Census of Manufacturers, Preliminary Report (November, 1964), p 11.

Other Electrical Industrial Equipment and Machinery

The remainder of the electrical-machinery industry (electrical industrial apparatus, including motors and generators and the residual, other electrical machinery) has been one of the fastest growing sectors of the economy. Nationally, in 1958, it accounted for 1.99 per cent of gross national product; by 1963, its share had risen to 2.44 per cent. The explanation for this national growth is that a major component of the industry is electronics. It is assumed that this growth pattern will continue through 1980. A national projection is made on the basis of the assumption that future labor productivity would continue to increase at its past rate of 3.6 per cent per year. In light of the present skills of its labor force, the Area is expected to share in this expected national growth. As a result, employment in other electrical machinery in the Area is projected to rise from 1.2 thousand in 1960 to over 17 thousand by the year 2020.

Presently, persons employed in the motors and generators industry in the Area are primarily engaged in the manufacture of units for the appliance industry. Thus, employment in this industry is projected to be partially determined by employment trends in the appliance industry. However, employment in motors and generators is expected to grow more rapidly than employment in household appliances, since firms in this industry are likely to participate heavily in future industrial demands for automated and semiautomated equipment. Therefore, employment in motors and generators is projected to rise from 1.8 thousand in 1960 to 9.6 thousand by 2020.

I-31. Transportation Equipment

Transportation equipment, which includes the manufacture of motor vehicles and equipment, is the most important single industry to the future economic health of the region and the Area. As indicated above, employment in many other industries depends on the level of activity in the transportation-equipment industry. In 1960, this major industry employed 38.7 thousand people in the Area, all but 2.6 thousand of whom were engaged in the manufacture of motor vehicles and equipment. Consequently, a detailed analysis of future employment trends in transportation equipment has been undertaken.

Employment in Motor Vehicles and Equipment

Future employment in the manufacture of motor vehicles and equipment in the Area is perhaps the most critical element in the future economic prosperity and growth of the Area. At the same time, projections of employment trends in this industry nationally, in the Region, or in the Area are critically dependent upon the assumptions made about future national demand for automobiles and future trends of labor productivity in this industry.

At the outset of the analysis of the demand for auto production in the period 1960-2020, several basic assumptions were adopted, which are representative to the assumptions necessary for developing projections in other detailed industries. It was assumed that autos, or a substitute therefore produced by the current auto industry, would continue to be the primary means of personal travel throughout the time period. This involves secondary assumptions to the effect that there will be no raw material or fuel shortages to restrict the realization of this assumption. It is further assumed that highways and parking will be adequate for the car population.

The difficulties in projecting motor-vehicle output (and employment) is illustrated by one authoritative study, which projected an annual output in the year 2000 ranging from 16.9 million to 73.7 million automobiles, a range in excess of 435 per cent of the lower limit.*

Although a number of methodologies were examined and tested, the final method adopted for projecting employment in motor vehicles and equipment is to combine projections of demand for motor vehicles with an analysis of likely trends in productivity in order to determine employment. Employment in the Area and in the Region in this industry are determined as derivatives of the projected national employment. Consequently, the bulk of the analysis focuses on national trends. This is of course appropriate, for the demand for the Region's and the Area's output will be determined nationally rather than by economic and demographic trends within the Region or the Area.

The first step in the analysis is to select a national population estimate for the target year, 2020. As detailed in previous

*Landsberg, Fischerman, and Fisher, Resources in America's Future (1963), p 132.

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sections on population, the projected national population for that year is 470.4 million. This number serves as the base for the derivation of likely future demand for automobiles. That demand and the employment necessary to produce cars to satisfy that demand are estimated by proceeding through the following steps:

(1) Project the number of passenger cars which will be in existence in the target year by determining the number of persons there will be in the population per automobile.

(2) From the projected total stock of automobiles, estimate the annual demand.

(3) By applying projected productivity estimates (in automobiles per worker), derive the number of workers necessary to supply the annual demand.

The employment for the Region and the Area are then derived on the basis of proportions of this projected national employment.

Estimate of Future Stock of Automobiles. Table 72 sets forth historical data for the period 1900 through 1960 showing the number of persons in the population per registered passenger car. These data are plotted on Figure 14. It may be observed that prior to the mid-1920's there was a dramatic decline in the number of persons per car, or conversely a dramatic rise in the number of cars per person, as annual sales were principally determined by new demand, rather than by the replacement of used vehicles. By the late 1920's, the number of persons per car began to decline at a much lower rate as the market became more nearly saturated and annual sales were determined by the rate of scrappage of the existing stock of automobiles as well as the entrance of some new car owners into the market.

Annual data for the period from 1950 to 1963 on the number of persons per car are set forth on Table 73 and shown graphically also on Figure 14. It may be observed that over the last 13 years there has been some continuation of the decline in the number of persons per car but at a very gradual rate. Analysis of both the long-term trend and the more recent trend in the number of persons per car indicates that significant declines into the future are unlikely. One recent study implicitly projects a figure

TABLE 72. NUMBER OF PERSONS PER CAR, 1900-1960

Year	Persons Per Car
1900	9,511.7
1905	1,082.9
1910	201.6
1915	43.1
1920	13.1
1925	6.6
1930	5.4
1935	5.7
1940	4.8
1945	5.5
1950	3.8
1955	3.2
1960	2.9

Note: Computed as number of persons residing in the United States per registered passenger car.

Source: U. S. Department of Commerce, Statistical Abstract of the United States (1963), p 5; Automobile Manufacturers Association, Automobile Facts and Figures (1964), p 18.

TABLE 73. NUMBER OF PERSONS PER CAR, 1950-1963

Year	Persons Per Car
1950	3.8
1951	3.6
1952	3.6
1953	3.4
1954	3.3
1955	3.2
1956	3.1
1957	3.0
1958	3.0
1959	3.0
1960	2.9
1961	2.9
1962	2.8
1963	2.8

Note: Computed as number of persons in the United States population per registered passenger car, including Alaska and Hawaii after 1958.

Source: U. S. Department of Commerce, Current Population Reports, Series P-25, Nos. 229, 272, 273; Automobile Manufacturers Association, Automobile Facts and Figures (1964), p 18.

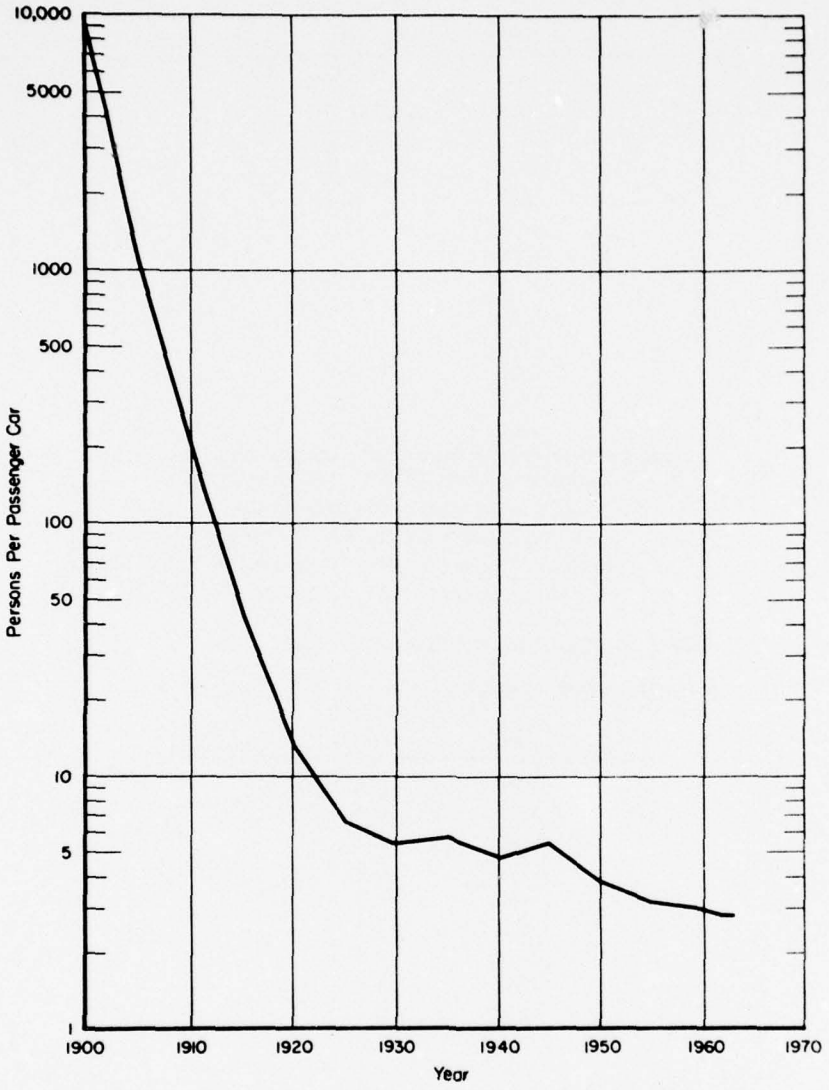

FIGURE 14. RATIO OF POPULATION RESIDING IN U. S. TO PASSENGER CAR REGISTRATIONS, 1900-1963

Source: U. S. Department of Commerce, Statistical Abstract of the United State (1963), p 5; Automobile Manufacturers Association, Automobile Facts and Figures (1964), p 18.

of 2.36 persons per car in 1980.* A judgmental projection of the historical and recent trend in the number of persons per car leads to a projected figure of 2.25 for the target year, 2020. For purposes of comparison, projections have also been made assuming that the number of people per car is 2.0, 2.5 and 2.75 in 2020.

Projection of Annual Sales. One of the most important factors determining annual sales of automobiles is variation in the proportion of sales to the stock (registrations) of cars. In the banner years 1950 and 1955, sales were 16.1 per cent and 14.7 per cent, respectively, of passenger car registrations. In most years, however, annual sales approximate 10 per cent of total registrations. In effect, the combination of new (first-time) car buyers and annual scrappage serve to give reasonable stability to this relationship.

The data in Table 74 represent the percentage which annual sales have been of passenger car registrations for the years 1950 through 1963. These data are also set forth on Figure 15. Examination of these data reveals that, while there has been significant year-to-year variation, the annual variation appears to cluster around a figure of sales equal to 10 per cent of registrations. Therefore, in Battelle's projection of automobile sales, derived from the projection of numbers of people per car, 10 per cent has been selected as the annual rate of sales.

There are arguments which can be made to suggest that in the future the ratio of annual sales to the stock of automobiles will (a) go up or (b) decline. If future consumers, as a result of higher incomes and differing tastes, tend to replace automobiles very rapidly, the estimate of 10 per cent is of course conservative. On the other hand, if future manufacturing techniques lead to a more "durable" automobile, there will be a corresponding tendency for replacement demand to decline relative to total registration, and the 10 per cent annual estimate will overstate annual demand.

Estimate of Annual Employment. As indicated above, the annual employment required to produce the projected annual

*D. Goldberg in Haber, Spivey and Warshaw, ed., Michigan in the 1970's, An Economic Forecast (1965), p 153. Goldberg projects the number of registered cars per household to be 1.44 in 1980. Assuming that the average household in that year contains 3.4 persons, it is possible to derive an estimate of the number of persons per car as 2.36.

TABLE 74. ANNUAL PASSENGER CAR SALES AS PER CENT OF TOTAL PASSENGER CAR REGISTRATIONS, 1950-1963

Year	Sales, thousands	Registrations, thousands	Sales, per cent of registration
1950	6,504	40,334	16.1
1951	5,068	42,683	11.9
1952	4,149	43,818	9.5
1953	5,926	46,422	12.8
1954	5,350	48,461	11.0
1955	7,661	52,136	14.7
1956	5,610	54,201	10.4
1957	5,935	55,906	10.6
1958	4,122	56,871	7.2
1959	5,469	59,562	9.2
1960	6,525	61,559	10.6
1961	5,394	63,260	8.5
1962	6,743	65,929	10.2
1963	7,433	68,452	10.9

Source: Automobile Manufacturers Association, Automobile Facts and Figures (1964), pp 5, 18.

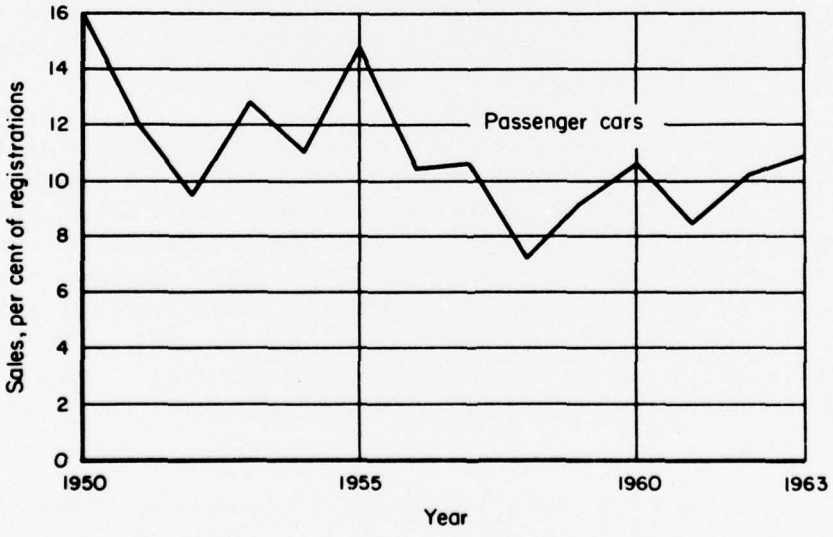

FIGURE 15. DOMESTIC MOTOR VEHICLE SALES AS A PER CENT OF PASSENGER CAR REGISTRATIONS, 1950-1963

Excludes sales to federal Government agencies.
Source: Automobile Manufacturers Association, Automobile Facts and Figures (1964), pp 5, 18.

demand for motor vehicles will be determined by future trends in productivity of workers in the motor-vehicle industry. Two measures shed some light on recent trends in productivity in this industry. These are value added per worker and number of automobiles produced per worker per year.

Statistics on value added per employee are of course subject to variation, depending on the price of the product. Consequently, the annual value-added data for motor-vehicle manufacture has been deflated by the appropriate wholesale price index in order to derive a "constant dollar" series on value added per employee. These data are set forth in Table 75.

In 1954, the value added per employee in motor vehicle manufacture was $10,418. By 1963, value added per employee had increased to over $18,200, an annual rate of increase in excess of 5 per cent. The data set forth in Table 75 are also on Figure 16. While it is clear that there have been significant year-to-year variations as well as deviations from the longer-term trend, productivity by this measure has been increasing rapidly in the industry, at least since 1954.

Data on the number of passenger cars produced per worker* are set forth on Table 76 and also on Figure 16. In 1956, there were 7.3 passenger cars produced for each employee in motor-vehicle and equipment manufacture. By 1963, output had risen to more than 10.3 vehicles per worker. Between 1956 and 1963, there was, on the average, an annual increase of approximately 5.0 per cent per year in the production per worker as indicated by this measure.

Obviously, the greater the future rate of increase in productivity projected for workers in this industry, the less will be future employment, once the levels of output have been determined. There is no reason to expect that there will be no future increase in output per worker in this industry. In fact, recent history strongly points to the contrary. However, discussions with many students of the industry indicate that past increases in productivity are not apt to be duplicated continuously into the future. We have generally accepted this position and selected an annual rate of increase in output per worker of 1.75 per cent, although our analysis

* These data are not directly comparable with the value added per worker data set forth on Table 75. However, the trends in the two series may be meaningfully compared.

TABLE 75. INDEX OF VALUE ADDED PER WORKER IN MOTOR-VEHICLE MANUFACTURE, UNITED STATES, 1954-1963

Year	Value Added Per Employee Index[a]
1954	83
1955	106
1956	93
1957	95
1958	92
1959	112
1960	114
1961	116
1962	137
1963	144

Source: U. S. Department of Commerce, Bureau of the Census, 1958 Census of Manufacturers, Vol. II, Industry Statistics, Table 1, pp 37-41.
U. S. Department of Commerce, Bureau of the Census, Annual Survey of Manufacturers, 1962, Table 1, p 42.

(a) Index computed on the basis of value added per employee in constant 1957-1959 dollars.

TABLE 76. PASSENGER CAR PRODUCTION PER WORKER, 1956-1963

Year	Cars Per Worker
1956	7.3
1957	8.0
1958	7.0
1959	8.1
1960	9.3
1961	8.7
1962	10.0
1963	10.3

Note: Computed as annual production of passenger cars divided by annual average number of all employees in SIC371.

Source: Automobile Manufacturers Association, Automobile Facts and Figures (1964), p 9; U. S. Department of Labor, Employment and Earnings Statistics in the United States, 1909-1964, p 261.

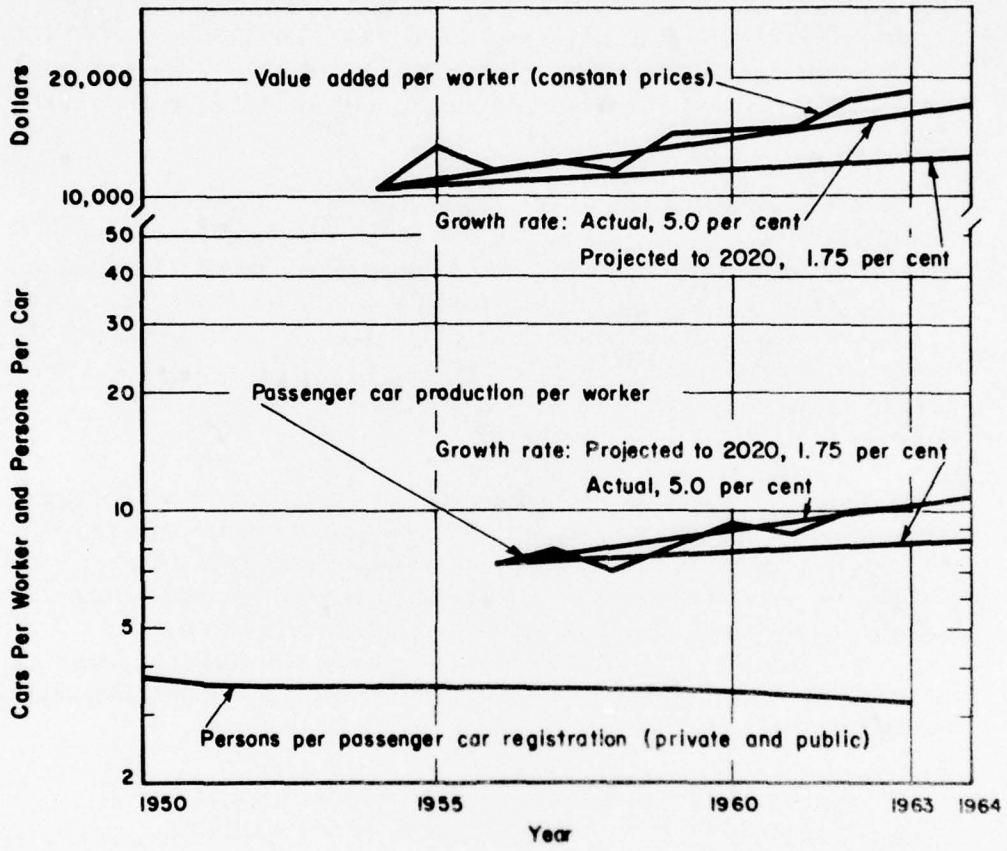

FIGURE 16. VALUE ADDED, PRODUCTION PER WORKER, PERSONS PER PASSENGER CAR, AND GROWTH RATES, UNITED STATES, 1950-1963

Sources: Automobile Facts and Figures (1954), Automobile Manufacturers Association, pp 9, 18.
Current Population Reports, Series P-25. Nos. 229, 272, 273.
Employment and Earnings Statistics for the United States, 1909-1964, p 261.

has also included examination of projections based on assumed annual rates of increase in productivity of 1.00 per cent, 1.50 per cent and 2.00 per cent.

In the year 2020, population will reach 470.4 million people. For there to be 2.25 people per car in that year, the stock of automobiles (registrations) must equal 209 million vehicles. Assuming that annual production is equivalent to 10 per cent of this stock, 20.9 million passenger vehicles will be produced in the year 2020.

In the most recent years, 1962 and 1963, there have been 10 cars produced for each employee in the motor vehicle and equipment industry. If productivity (output per worker) increases at the rate of 1.75 per cent per year* to the year 2020, there will be 28.2 automobiles produced for each worker in the industry. Given an annual demand of 20.9 million cars, there will thereby be 741 thousand employees in the motor vehicle and equipment industry.

Table 77 contains data showing the projected levels of employment for the industry under various combinations of assumptions with regard to the annual rate of productivity increase and the number of persons per car, all based on the initial assumption of a national population of 470.4 million in 2020. As the data in Table 77 indicate, the following assumptions all yield an employment level in the industry of between 700 and 800 thousand workers workers:

(A) Two persons per car and an annual rate of increase in productivity of 2.00 per cent

(B) 2.25 persons per car and an annual productivity increase of 1.75 per cent per year

*This is substantiated by an independent regression analysis provided by Mr. Leonard Bronder, a member of the Advisory Committee. His correlation of changes in production with changes in productivity indicated that if there had been no changes in level of production, the expected change in productivity (natural productivity increase) would have been 1.8 per cent during the postwar period. His equation is

$$y = 1.8 + .56x \quad ,$$

where y is per cent change in autos produced per worker and x is per cent change in production. He obtained a coefficient of correlation, r, of 90.6, using 14 observations.

TABLE 77. SUMMARY OF NATIONAL EMPLOYMENT PROJECTIONS FOR MOTOR VEHICLES AND EQUIPMENT, 2020

		Employment, thousands			
	Persons Per Car:	2.00	2.25	2.50	2.75
	Production, million:	23.5	20.9	18.8	17.1
Rate of Productivity Increase, per cent	Cars Per Employee				
1.00	18.2	1,291	1,148	1,033	940
1.50	24.4	963	857	770	701
1.75	28.2	833	741	667	606
2.00	32.8	716	637	552	321

TABLE 78. MICHIGAN EMPLOYMENT AS A PER CENT OF U. S. EMPLOYMENT IN MOTOR VEHICLES AND EQUIPMENT, 1956-1964

	Employment, thousands		Michigan Employment,
Year	Michigan	United States	per cent of U. S.
1956	411.7	792.5	51.9
1957	387.7	769.3	50.4
1958	288.5	606.5	47.6
1959	303.4	692.3	43.8
1960	311.2	724.1	43.0
1961	274.3	632.3	43.4
1962	313.0	691.7	45.3
1963	329.9	745.2	44.3
1964	347.4	771.0	45.1

Source: Michigan Employment Security Commission.

(C) 2.50 persons per car and an annual rate of increase in productivity of 1.50 per cent

(D) 2.75 persons per car and an annual rate of increase in productivity of 1.50 per cent.

As pointed out above, Battelle's analysis indicates 2.25 persons per car by 2020 and an annual rate of productivity increase no less than 1.75 per cent per year.

In recent years, the share of total employment in motor vehicles and employment in the Region has shown some decline. In 1956, the State accounted for nearly 52 per cent of national employment in this industry. By 1960, the State's share had fallen to 43 per cent, but since that time it has increased erratically, and it reached 45.1 per cent of the national level in 1964. These data are set forth on Table 78. Some researchers, undertaking analysis in the late 1950's observed the decline in Michigan's share of national employment and projected that decline to continue.* The more recent data (since 1960) indicate that the decline in the state's share has perhaps bottomed out.** While there will doubtless continue to be year-to-year fluctuation as the industry's output fluctuates, the recent data suggest that the State's share will, on average, remain constant at 43.5 per cent of national employment. Applying this share to the projected national employment of 741,000 by 2020 yields a projected employment for that year of 322,000 in the Region.

In recent years, the employment in motor vehicles and equipment in the Area has not declined (relative to national employment) as rapidly as in the State. However, the assumption that the State's share will no longer continue to decline leads to the further assumption that employment in this industry in the Area will remain stable relative to employment in the State. In 1960, employment in the Area was equivalent to 9.9 per cent of that in the State.

*See for instance, Economic and Population Base Study of the Lansing Tri-County Area, 1960.

**Mr. Samuel Stearn, Michigan Employment Security Commission, provided data which indicate that Michigan's share of U.S. employment in motor vehicles has declined from a monthly average of 51.9 per cent in 1956 to a low of 43.0 per cent in 1960. During the past 3 years (1962, 1963, 1964), Michigan's share equalled 45.3 per cent, 44.3 per cent, and 45.1 per cent, respectively. These data are based on the revised data series which describe "covered" employment as reported in Employment and Earnings, issued by the Bureau of Labor Statistics in the U.S. Department of Labor.

For purposes of projection, future employment in the Area is estimated as 10 per cent of that in the State. Consequently, an employment level is projected of 32,200 in motor vehicles and equipment in the Area by the year 2020.

These projections, and the methodology underlying them are all derived from analysis of Bureau of Labor Statistics data. The final projections for employment in the Area, for all industries, are based on Census data and consequently are not directly comparable with the BLS data. For instance, in 1960, the BLS reported a Michigan employment of 311.2 thousand workers in the industry; the decennial Census reported 377 thousand. (No comparable data are available for 1960 for the Area.) Discussions with representatives of the Michigan Employment Security Commission have led to the conclusion that these apparent disparities result from differences in definition and classification of segments of the industry. Therefore, it is necessary to modify these initial projections, to obtain projections on a basis consistent with those for other industries and for the 1960 base-year data. This adjustment is made by applying the 1960 ratio of employment as reported by the Census to employment as reported by BLS to the projected employment levels which are in terms of BLS data. As a result, Michigan employment in this industry is projected to increase from 377 thousand in 1960 to 390 thousand by 2020. Employment in the Area is projected to increase from 36.1 thousand in 1960 to 39.0 thousand in 2020. The detail for the intervening years and the projected employment levels in terms of both BLS data and Census data are set forth in Table 79.

Employment in Other Transportation Equipment

As indicated above, employment in the transportation-equipment industry in the Area, other than in the manufacture of motor vehicles and equipment, was relatively small in 1960. This industry includes employment in the manufacture of trucks and buses as well as aircraft. Nationally, it is expected that this industry will experience substantial growth over the next 60 years. This upward trend has been reflected in the projected employment levels in other transportation equipment in the Area. As a result, employment is projected to increase from 2.6 thousand in 1960 to approximately 7,000 by the year 2020.

TABLE 79. PROJECTED EMPLOYMENT IN MOTOR-VEHICLE INDUSTRY, 1970-2020

	1960	1970	1980	1990	2000	2010	2020	Source
U. S. Population, millions	179.3	209.0	245.3	288.2	338.2	399.3	470.4	(a)
Persons per Car	2.9	2.55	2.38	2.30	2.28	2.25	2.25	(b)
Production of Cars, thousands	6,703	8,200	10,300	12,500	14,800	17,800	20,900	(b)
Productivity, cars per worker	9.3	11.9	14.1	16.8	20.0	23.8	28.2	(b)
Employment, U. S., thousands	724.1	689	730	744	740	748	741	(c)
Employment, U. S., thousands	841.9	801	849	865	860	870	862	(d)
Michigan Employment, thousands	311.2	300	318	324	322	325	322.3	(e)
Michigan Employment, thousands	377	364	385	393	390	394	390	(d)
Area Employment, thousands	na	30.0	31.8	32.4	32.2	32.5	32.2	(f)
Area Employment, thousands	36.1	36.4	38.5	39.3	39.0	39.4	39.0	(d)

(a) 1960: Census of Population.
1970-2010: Census Series B.
2020: Battelle projection.

(b) Battelle Memorial Institute.

(c) 1960: Bureau of Labor Statistics.
1970-2020: Comparable Battelle projections.

(d) 1960: Census of Population.
1970-2020: Comparable Battelle projections.

(e) 1960: Michigan Employment Security Commission.
1970-2020: Comparable Battelle projections.

(f) 1970-2020: Battelle projections comparable to Michigan Employment Security Commission data.

I-32. Professional, Scientific, and Controlling Instruments

This major industry includes establishments engaged in manufacturing mechanical measuring, engineering, laboratory, and scientific instruments and lenses, surgical, medical and dental instruments, and similar equipment. In the Area, the subindustry, scientific instruments, accounted for 4.2 of the major industries' 4.4 thousand employment in 1960. This employment is at the Lear Siegler Corporations' instrument division in Grand Rapids. Presently, the instrument division's production is approximately 99 per cent dependent on Department of Defense contracts. Since 1960, there has been a major cutback in employment at this establishment, and there are presently about 2700 employees. In light of these recent cutbacks and the uncertain future of firms so heavily dependent on defense, the employment in scientific instruments in the Area is projected to remain constant from 1970 through 2000. Some small increases are included in 2010 and 2020.

The remainder of this industry in the Area (other instruments) accounted for the employment of only 200 people in 1960. However, in light of likely technological trends in the nation and the nature of the output of this industry, it is anticipated that national employment will increase. In all likelihood, the Area will share in these long term gains. As a result, employment in other instruments is projected to increase from 200 in 1960 to approximately 800 by 2020.

I-33. Other Durable Goods Manufacturing

This residual group includes a conglomerate of industries. In 1960 3.1 thousand people were employed in other durable goods manufacturing. The total for other durable manufacturing in the Area is projected to rise substantially from the 1960 level of 3.1 thousand to 25.6 thousand by the year 2020. This projection is a residual and is based on the over-all projection for manufacturing employment in total.

I-34. Food and Kindred Products

The food and kindred products industry, which includes bakery products, employed 8. 9 thousand in the Area in 1960. Analysis of future consumer demand, nationally, strongly indicates that the food and kindred products industry (food processing) will expand slowly in the future. It is expected that expansion in the industry in the Area will parallel this national trend. As a result, employment in bakery products in the Area is expected to increase from 3. 6 thousand in 1960 to 4. 2 thousand by 2020. The major group, food and kindred products, employment is projected to rise from 8. 9 thousand in 1960 to 12. 2 thousand by 2020.

I-35. Leather Products

Leather products (including footwear) employed 2. 3 thousand in the Area in 1960. The growth of substitutes and expected increases in productivity do not indicate a substantial growth in employment in this industry in the future. Consequently, leather products' employment is projected to rise in the Area from 2. 3 thousand in 1960 to 2. 8 thousand by 1970 and 2. 9 thousand by 1980. Thereafter, it is projected to remain stable. A similar pattern is anticipated for footwear manufacture, showing an increase from 1. 2 thousand in 1960 to 1. 5 thousand in 1970 and relative stability thereafter.

I-36. Printing and Publishing

This industry employed 6. 4 thousand people in the Area in 1960. It is an industry wherein significant employment effects due to increased productivity (through automation) are anticipated in the future. As a result, employment is projected to fall in the Area from 6. 4 thousand in 1960 to 5. 8 thousand by 1980. Thereafter, it is anticipated that general growth in demand for printing and publishing output will have a more significant effect on the industry's employment than will changes in productivity. As a result, employment in this industry in the Area is projected to rise from 5. 8 thousand in 1960 to 8. 6 thousand by 2020.

I-37. Rubber and Plastic Products

This industry, which includes tires and innertubes, employed 2.4 thousand people in the Area in 1960. Employment in tires and innertubes accounted for 1.6 thousand of this total.

The employment in tires and innertubes in the Area is in a single plant. It is not anticipated that this plant will expand appreciably in the future, and increases in productivity will doubtless lead to some cutback in employment. Consequently, employment is projected to fall from 1.6 thousand in 1960 to a level of 500 by 2020.

The other rubber products industry employed only 800 people in the Area in 1960. However, this industry nationally includes both fabricated rubber products and miscellaneous plastic products. Nationally, it is expected to grow, principally through expansion of plastics. This growth is assumed to be shared by this industry in the Area. As a result, employment is projected to increase from 800 in 1960 to reach a level of 6.5 thousand by 2020.

I-38. Other Nondurable Manufacturing

This industry, as in the case of other durable manufacturing, is a residual. Employment in this group in the Area was 5.8 thousand in 1960. Employment in other nondurables is projected in the same way as other durable manufacturing. Total employment in this residual group is projected to increase from 5.8 thousand in 1960 to 24.4 thousand by 2020.

The projections for each of the industries, as set forth above, including the detailed projections within manufacturing were combined in this analysis into broad aggregate groups. The past structure of occupation of those employed in these industries was analyzed and projected in light of the projected total-employment estimates. As a result, future employment by occupation for those who will be living in the Area was projected. Just as in the case of the national projections, these projections of employment by occupation were translated into employment by level of educational attainment. This projection was then compared with the projected supply of people in the labor force by level of educational attainment

in order to determine whether the projected supply (derived from population) was realistic in light of the projected demand. In the case of the Area, it was apparent that there will be some excess demand for people with college training. However, the gap between projected demand and supply is much less significant in the Area than is projected nationally. As a result, it was assumed that employment equilibrium will not be difficult in the Area. The gap in supply of trained people can be filled through the employment of slightly less than fully trained individuals, through improved production techniques which require lesser skill levels, and/or by the net differential migration into the Area of skilled persons.

The final projections of employment and detail of industry for the Area are set forth on Table 58.

I-39. Value Added in Key Water-Using Industries

The discussion in the previous section of projected employment includes projected employment for those industries identified as "key" in terms of water use. Projections of value added have been made for these industries. Included in this group are tires and innertubes; miscellaneous primary metals; cutlery, hand tools, and hardware; metal stampings; household appliances; and motor vehicles.

In the case of motor vehicles, value added (in constant dollars) per employee was projected at the same rate (1.75 per cent per year) as the projected output, in numbers of cars per worker, discussed in the section on motor vehicles and equipment employment. For the remaining five industries, a detailed analysis was undertaken of past trends in both value added per employee (see Table 80) and the relationship between value added per employee in each of these industries and value added per employee in all durable goods.* The differential rates of change in productivity in each of these industries as compared to durable goods was examined. This analysis was undertaken on a constant-dollar basis

*Even though tires and innertubes are classified as a nondurable manufacturing activity, it is believed that productivity in this industry is more closely related to that of durable goods manufacture than to nondurable goods manufacture.

TABLE 80. INDEX OF VALUE ADDED[a] BY SELECTED INDUSTRIES IN THE AREA, 1960-2020

(Index Computed on Basis of Constant 1960 Dollars)

Industry	1960	1970	1980	1990	2000	2010	2020
Tires and Inner Tubes							
Value Added per Employee	100	147	215	267	332	413	513
Total Value Added	100	100	119	132	143	153	158
Miscellaneous Primary Metals							
Value Added per Employee	100	131	167	207	258	321	398
Total Value Added	100	157	217	280	361	465	597
Cutlery, Hand Tools, and Hardware							
Value Added per Employee	100	131	167	207	258	321	398
Total Value Added	100	138	158	218	284	369	478
Metal Stampings							
Value Added per Employee	100	131	167	207	258	321	398
Total Value Added	100	147	205	272	354	461	622
Household Appliances							
Value Added per Employee	100	175	273	340	422	525	652
Total Value Added	100	241	362	450	549	670	815
Motor Vehicles							
Value Added per Employee	100	119	141	168	200	238	283
Total Value Added	100	120	151	183	216	260	306

Source: (1970-2020) Battelle estimates and projections.

(a) Since data are not available in certain counties (problem of individual firm's disclosure) the value-added estimates for 1960 were established by using State and National relationships. Therefore, these indices are rough indicators of expected productivity trends in the area.

(deflating value added per employee in each industry by the appropriate wholesale price index). An examination of the trend since 1954, on an annual basis, revealed that miscellaneous primary metals; cutlery, hand tools, and hardware; and metal stampings appeared to closely parallel durable goods. Value added per employee in tires and innertubes and in household appliances has been increasing more rapidly than durable goods. Value added per employee in these two industries was projected to continue to increase more rapidly than for all durable goods but at progressively lower rates, between 1960 and 1980. Thereafter, it was assumed that value added per employee in these two industries would increase at the same rate as projected for all durable goods manufacture.

Since this analysis was based on the relationship between value added per employee in each of the industries and value added per employee in durable goods, it was necessary to make a projection of value added per employee for all durables in order to project value added per employee for the individual industry. This projection was undertaken in detail from the period 1960 through 1980, and thereafter it was assumed that value added per employee in durable goods would increase at an annual rate of 2.0 per cent per year. For the projection covering 1960 through 1980, output per worker (value added) was examined for each major industry group historically. This analysis was done on the basis of national income (approximately equivalent to value added) originating in each major industry division. The historical data indicate that the ratio of value added per employee in durable goods to value added in all industries has been increasing, at least since 1946. In 1960, value added per employee in durable goods was 104.5 per cent of value added per employee for all industries. It is projected that by 1970 value added per employee in durable goods will be equal to 107.0 per cent of value added per employee for all industries. This ratio will continue to increase until 1980.

Total U.S. national income has been projected to 1970 and 1980, as has total employment. Consequently, it is possible to estimate value added per employee for all industries in 1970 and in 1980. Application of the trend in value added per employee in durable goods to value added per employee in all industry gives an estimate of value added per employee in durable goods for 1970 and 1980. The projected trends for the individual key industries are then applied to the projected value added per employee for durable goods in order to estimate value added per employee for

each of the key industries. These estimates are then applied to the projected employment in each of these industries in the Area to derive a value added by industry estimate for each of the years in the projection period. Indices of value added per employee as well as projected total value added by the industry in the Area are set forth in Table 80.

I-40. Area Employment by Industry and Subarea

Projections have been developed for major industry divisions by subarea. These projections are developed through allocation of the projected employment levels for the Area, the derivation of which was described in the preceding sections. As a general methodology, historical data for 1940, 1950, and 1960 were the basis for a trend analysis of the changing relative share of industry-division employment located in each of the five subareas. However, two fundamental judgments were made which affected the evolution of the trend.

Two of the five subareas, the West Central Belt and the Northeast Fringe, may be considered as nonmetropolitan areas. The behavior of these areas during the past two decades does not provide a solid basis for trend analysis for the future, given the changing character of industry structure over all in the Area. In 1940, these nonmetropolitan areas accounted for 13.1 per cent of the Area's employment in manufacturing. By 1950, this share had increased to 16.5 per cent and by 1960 to 19.5 per cent. An extension of this trend would in effect result in the nonmetropolitan areas becoming the manufacturing center of the Area. This would be especially true in view of the projected relatively slow growth in manufacturing employment. Whereas manufacturing accounted for 34.4 per cent of total employment in the Area in 1960, it is projected to decline to 31.5 per cent in 1980 and 23 per cent in 2020, despite the fact that the absolute level of employment in manufacturing increases from 134.7 thousand in 1960 to 172.8 thousand in 1980, and 229.5 thousand in 2020. In the allocation of Area employment by subareas, it was assumed that the nonmetropolitan subareas' share of total Area employment would not exceed 20 per cent. The projected share of manufacturing found in nonmetropolitan areas for 1970 is 19.8 per cent; in 1980 it is 20 per cent, and this level is assumed constant throughout the remainder of the projection period.

The second fundamental judgment made concerning the employment by subareas relates to the services sector. The growth in service industries is affected by the population distribution among the subareas, as adjusted. Of course, the nonmetropolitan areas reflect the changing basic structure of the Area's employment. For example, services in the West Central Belt are projected to rise from 16.6 per cent of total employment in that subarea in 1960 to 19.5 per cent in 1980 and to 21.9 per cent in 2020. Likewise in the Northeast Fringe, services are expected to increase from 18.5 per cent of total employment in 1960 to 22.7 per cent in 1980 and to 25.5 per cent in 2020. While the portion of employment found in services in nonmetropolitan areas is less than the 30.0 per cent found in the Area as a whole, the trend throughout the projection period is similar. This is a natural result of the projection methodology, which focuses on the allocation of the Area's total employment by major industry division among the various subareas. This allocation is accomplished in terms of the two fundamental judgments outlined above and the basic relative structure of the subareas during the past two decades. Projected levels of employment by industry by subarea are presented in Table 81. The distribution of employment within each subarea and across the major industry divisions is presented in Table 82. The relative share of the Area's employment found in each of the subareas is presented in Table 83.

A convenient summary of the relevant trends is provided by Table 84, which presents compound annual growth rates for employment by industry by subarea for the 1960-1980 and 1960-2020 periods. This table illustrates the relative growth patterns anticipated for the five subareas. For the period 1960-1980, the Grand Rapids and Lansing subareas are expected to grow at rates equal to or greater than the Area average, whereas the West Central Belt, Northeast Fringe, and Jackson subareas are expected to grow at less-than-average rates. When manufacturing employment is considered, the Lansing subarea, which has the highest over-all rate of growth, has the lowest growth rate for manufacturing. This reflects the stabilization of the automobile employment levels and the fact that Lansing's growth will be found particularly in the service areas, with special reference to professional and related services and public administration. Another summary of the subarea projections is provided in Tables 85 to 89, which summarize growth in population 14 years and over, in labor force participation, in labor force size, in employment levels, and in unemployment levels and rates. In particular, these tables may

be compared with Table 57 which presents the summary of these same factors for the whole Area. The balanced economic growth projected for Lansing throughout the projection period is evident from the relatively low unemployment rates projected for the subarea, 3.9 per cent in 1980 and 3.3 per cent in 2020. In contrast, the Jackson subarea, even though contiguous to the Lansing subarea, is projected to have a less balanced development, and hence the unemployment rate in the Jackson subarea will continue to reflect differential with respect to Lansing. In 1960 unemployment in Jackson was 6.4 per cent compared with 4.6 per cent in Lansing. This spread continues with a projected unemployment rate of 5.8 per cent for Jackson and 3.9 per cent for Lansing in 1980 and 5.2 per cent for Jackson and 3.3 per cent for Lansing in 2020.

Projections of employment and value added for selected key industries in a number of the subareas have been prepared, also on the basis of the allocation methodology. The results of these projections are shown in Tables 90 and 91.

TABLE 81. EMPLOYMENT BY INDUSTRY IN THE SUBAREAS, 1960-2020

Subarea and Industry	1960	1970	1980	1990	2000	2010	2020
GRAND RAPIDS							
Agriculture, forestry, and fisheries	5,200	4,900	3,900	3,700	3,700	3,400	3,300
Mining	300	300	300	400	400	500	600
Contract construction	8,800	10,100	11,500	13,600	15,900	18,900	22,000
Manufacturing	62,600	74,800	85,500	95,400	104,100	111,600	117,400
Durables	48,300	58,100	65,800	73,100	78,900	83,100	85,600
Nondurables	14,300	16,700	19,700	22,300	25,200	28,500	31,800
Transportation, communication, and utilities	10,000	10,600	11,600	12,700	14,100	15,600	17,500
Wholesale and retail trade	32,700	41,500	47,900	56,100	64,100	74,900	88,300
Finance, insurance, and real estate	6,300	8,500	12,300	16,500	20,400	22,800	24,000
Services	32,800	39,600	45,700	58,900	73,000	92,200	117,300
Public administration	4,200	5,500	7,300	9,500	12,700	17,100	23,100
Industry not reported	3,900	5,300	6,400	9,300	10,300	12,400	15,200
Total, All Industries	166,800	201,100	232,400	276,000	318,600	369,500	428,600
WEST CENTRAL BELT							
Agriculture, forestry, and fisheries	4,700	4,600	4,000	3,900	3,800	3,600	3,400
Mining	100	100	100	100	100	100	100
Contract construction	1,700	1,800	2,000	2,300	2,700	3,200	3,500
Manufacturing	14,700	17,400	19,200	21,200	22,700	24,400	25,500
Durables	11,900	14,200	15,500	17,000	18,100	19,100	19,500
Nondurables	2,800	3,200	3,700	4,100	4,600	5,300	6,000
Transportation, communication, and utilities	1,300	1,400	1,500	1,700	1,800	2,000	2,100
Wholesale and retail trade	5,800	7,200	8,500	9,800	11,000	12,700	14,400
Finance, insurance, and real estate	800	1,000	1,500	2,000	2,400	2,700	2,700
Services	6,300	8,000	9,800	11,300	13,100	14,900	16,900
Public administration	1,100	1,500	1,900	2,500	3,300	4,400	5,600
Industry not reported	1,200	1,100	1,600	1,900	2,100	2,500	2,900
Total, All Industries	37,700	44,100	50,100	56,600	63,000	70,300	77,200

Note: Totals may not add due to rounding and are calculated on basis of unrounded numbers.

TABLE 81. (Continued)

Subarea and Industry	1960	1970	1980	1990	2000	2010	2020
LANSING							
Agriculture, forestry, and fisheries	5,700	5,500	4,900	4,600	4,500	4,300	4,100
Mining	100	100	100	100	200	200	200
Contract construction	6,600	8,100	10,000	11,900	13,900	16,500	19,000
Manufacturing	29,500	33,100	33,000	35,700	38,100	40,100	41,400
Durables	25,200	28,400	28,000	30,200	31,900	33,000	33,300
Nondurables	4,300	4,700	4,900	5,500	6,200	7,100	8,000
Transportation, communication, and utilities	4,900	5,500	6,200	6,900	7,700	8,400	9,400
Wholesale and retail trade	19,600	25,300	30,300	35,500	40,500	47,200	55,000
Finance, insurance, and real estate	4,300	5,800	8,500	11,500	14,200	15,800	16,500
Services	28,400	38,300	49,600	63,800	77,100	94,700	117,100
Public administration	7,200	9,800	13,300	17,500	23,300	31,100	41,300
Industry not reported	3,800	3,600	5,500	6,600	7,300	8,800	10,600
Total, All Industries	110,300	135,200	161,600	194,200	226,800	267,000	314,500
NORTHEAST FRINGE							
Agriculture, forestry, and fisheries	3,100	3,000	2,700	2,700	2,700	2,500	2,400
Mining	100	100	100	100	100	100	100
Contract construction	1,300	1,500	1,600	1,900	2,200	2,500	2,800
Manufacturing	11,600	13,900	15,400	17,000	18,300	19,600	20,400
Durables	9,600	11,500	12,600	13,900	14,800	15,600	15,900
Nondurables	2,000	2,400	2,700	3,100	3,500	4,000	4,500
Transportation, communication, and utilities	2,200	2,200	2,400	2,500	2,700	2,900	3,100
Wholesale and retail trade	5,200	6,200	7,000	8,000	9,100	10,300	11,600
Finance, insurance, and real estate	700	1,000	1,500	2,000	2,500	2,700	2,700
Services	5,800	7,800	9,900	11,500	13,400	15,000	17,100
Public administration	900	1,100	1,600	2,000	2,700	3,500	4,500
Industry not reported	500	900	1,300	1,600	1,700	2,000	2,300
Total, All Industries	31,500	37,600	43,500	49,100	55,300	61,100	67,100

Note: Totals may not add due to rounding and are calculated on basis of unrounded numbers.

TABLE 81. (Continued)

Subarea and Industry	1960	1970	1980	1990	2000	2010	2020
JACKSON							
Agriculture, forestry, and fisheries	1,700	1,700	1,600	1,500	1,400	1,300	1,300
Mining	100	100	100	100	200	200	200
Contract construction	1,900	2,100	2,400	2,900	3,400	4,000	4,600
Manufacturing	16,300	18,700	19,800	21,400	22,900	24,100	24,900
Durables	12,800	14,800	15,500	16,700	17,700	18,300	18,500
Nondurables	3,500	3,900	4,300	4,700	5,300	5,900	6,400
Transportation, communication, and utilities	4,300	4,400	4,800	5,200	5,800	6,400	7,100
Wholesale and retail trade	8,300	10,400	12,200	14,300	16,300	19,000	22,100
Finance, insurance, and real estate	1,300	1,800	2,700	3,600	4,400	5,000	5,200
Services	8,500	10,700	13,100	16,700	20,300	25,000	30,900
Public administration	1,800	2,500	3,400	4,400	5,900	7,900	10,500
Industry not reported	1,500	1,400	1,900	2,600	2,800	3,400	4,100
Total, All Industries	45,800	53,800	61,900	72,700	83,500	96,300	110,900
AREA							
Agriculture, forestry, and fisheries	20,300	19,600	17,100	16,400	16,100	15,100	14,500
Mining	800	700	700	800	900	1,100	1,300
Contract construction	20,400	23,600	27,600	32,500	38,000	45,100	52,000
Manufacturing	134,700	157,900	172,800	190,700	206,100	219,800	229,500
Durables	107,800	126,900	137,500	151,000	161,400	169,000	172,800
Nondurables	26,900	31,000	35,300	39,700	44,700	50,800	56,700
Transportation, communication, and utilities	22,700	24,100	26,600	29,000	32,000	35,200	39,300
Wholesale and retail trade	71,700	90,600	105,900	123,600	141,000	164,000	191,500
Finance, insurance, and real estate	13,400	18,100	26,500	35,500	44,000	49,000	51,000
Services	81,800	104,400	128,000	162,100	196,900	241,800	299,300
Public administration	15,200	20,400	27,500	36,000	48,000	64,000	85,000
Industry not reported	11,000	12,400	16,800	22,000	24,200	29,000	35,000
Total, All Industries	392,000	471,900	549,500	648,600	747,200	864,100	998,300

Note: Totals may not add due to rounding and are calculated on the basis of unrounded numbers.
Source: 1960: U. S. Bureau of the Census; 1970-2020 Battelle projections.

TABLE 82. PERCENTAGE DISTRIBUTION OF EMPLOYMENT BY INDUSTRY IN THE SUBAREAS, 1960-2020

Subarea and Industry	1960	1970	1980	1990	2000	2010	2020
GRAND RAPIDS							
Agriculture, forestry, and fisheries	3.1	2.4	1.7	1.3	1.2	0.9	0.8
Mining	0.2	0.2	0.1	0.1	0.1	0.1	*
Contract construction	5.3	5.0	4.9	4.9	5.0	5.1	5.2
Manufacturing	37.5	37.2	36.8	34.6	32.7	30.2	27.4
Durables	28.9	28.9	28.3	26.5	24.8	22.5	20.0
Nondurables	8.6	8.3	8.5	8.1	7.9	7.7	7.4
Transportation, communication, and utilities	6.0	5.3	5.0	4.6	4.4	4.2	4.1
Wholesale and retail trade	19.6	20.6	20.6	20.3	20.1	20.3	20.6
Finance, insurance, and real estate	3.8	4.2	5.3	6.0	6.4	6.2	5.6
Services	19.7	19.7	19.7	21.3	22.9	25.0	27.4
Public administration	2.5	2.8	3.1	3.5	4.0	4.6	5.4
Industry not reported	2.3	2.6	2.8	3.4	3.2	3.4	3.5
Total, All Industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
WEST CENTRAL BELT							
Agriculture, forestry, and fisheries	12.5	10.5	8.0	6.9	6.0	5.1	4.4
Mining	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Contract construction	4.6	4.2	4.0	4.1	4.3	4.5	4.6
Manufacturing	38.9	39.4	38.3	37.4	36.0	34.7	33.0
Durables	31.6	32.1	31.0	30.1	28.7	27.2	25.3
Nondurables	7.3	7.3	7.3	7.3	7.3	7.5	7.7
Transportation, communication, and utilities	3.6	3.1	3.1	2.9	2.9	2.8	2.8
Wholesale and retail trade	15.4	16.4	16.9	17.3	17.5	18.1	18.7
Finance, insurance, and real estate	2.0	2.3	3.0	3.5	3.9	3.8	3.5
Services	16.6	18.2	19.5	20.0	20.8	21.2	21.9
Public administration	3.0	3.3	3.9	4.4	5.2	6.2	7.3
Industry not reported	3.2	2.5	3.2	3.4	3.3	3.5	3.7
Total, All Industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 82. (Continued)

Subarea and Industry	1960	1970	1980	1990	2000	2010	2020
LANSING							
Agriculture, forestry, and fisheries	5.1	4.1	3.0	2.4	2.0	1.6	1.3
Mining	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Contract construction	6.0	6.0	6.2	6.1	6.1	6.2	6.0
Manufacturing	26.8	24.5	20.4	18.4	16.8	15.0	13.2
Durables	22.9	21.0	17.4	15.6	14.1	12.3	10.6
Nondurables	3.9	3.5	3.0	2.8	2.7	2.7	2.6
Transportation, communication, and utilities	4.5	4.1	3.9	3.6	3.4	3.2	3.0
Wholesale and retail trade	17.8	18.7	18.8	18.3	17.8	17.6	17.5
Finance, insurance, and real estate	3.9	4.3	5.3	5.9	6.3	5.9	5.2
Services	25.7	28.3	30.7	32.8	34.0	35.4	37.2
Public administration	6.6	7.3	8.2	9.0	10.3	11.7	13.1
Industry not reported	3.5	2.6	3.4	3.4	3.2	3.3	3.4
Total, All Industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
NORTHEAST FRINGE							
Agriculture, forestry, and fisheries	9.7	8.0	6.3	5.5	4.8	4.2	3.6
Mining	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Contract construction	4.3	3.9	3.8	3.9	4.0	4.2	4.2
Manufacturing	37.0	37.0	35.3	34.5	33.1	32.0	30.5
Durables	30.5	30.6	29.0	28.2	26.8	25.4	23.7
Nondurables	6.5	6.4	6.3	6.3	6.3	6.6	6.8
Transportation, communication, and utilities	7.1	5.7	5.5	5.0	4.9	4.7	4.6
Wholesale and retail trade	16.6	16.5	16.1	16.3	16.4	16.8	17.3
Finance, insurance, and real estate	2.2	2.6	3.5	4.1	4.5	4.4	4.0
Services	18.5	20.6	22.7	23.2	24.1	24.6	25.5
Public administration	2.7	3.0	3.6	4.1	4.9	5.7	6.7
Industry not reported	1.7	2.5	3.0	3.2	3.1	3.2	3.5
Total, All Industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 82. (Continued)

Subarea and Industry	1960	1970	1980	1990	2000	2010	2020
JACKSON	3.7						
Agriculture, forestry, and fisheries	3.7	3.1	2.6	2.1	1.7	1.4	1.2
Mining	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Contract construction	4.2	4.0	3.9	4.0	4.0	4.2	4.2
Manufacturing	35.5	34.7	31.9	29.5	27.5	25.1	22.4
Durables	27.9	27.4	25.0	23.0	21.2	19.0	16.6
Nondurables	7.6	7.3	6.9	6.5	6.3	6.1	5.8
Transportation, communication, and utilities	9.3	8.2	7.7	7.2	6.9	6.6	6.4
Wholesale and retail trade	18.2	19.3	19.6	19.6	19.5	19.7	20.0
Finance, insurance, and real estate	2.8	3.3	4.3	4.9	5.3	5.2	4.7
Services	18.6	19.9	21.2	22.9	24.4	25.9	27.8
Public administration	4.0	4.6	5.5	6.1	7.1	8.2	9.5
Industry not reported	3.4	2.6	3.1	3.5	3.4	3.5	3.6
Total, All Industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0
AREA							
Agriculture, forestry, and fisheries	5.2	4.2	3.1	2.5	2.2	1.8	1.5
Mining	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Contract construction	5.2	5.0	5.0	5.0	5.1	5.2	5.2
Manufacturing	34.4	33.5	31.5	29.4	27.6	25.4	23.0
Durables	27.5	26.9	25.1	23.3	21.6	19.5	17.3
Nondurables	6.9	6.6	6.4	6.1	6.0	5.9	5.7
Transportation, communication, and utilities	5.8	5.1	4.8	4.5	4.3	4.1	3.9
Wholesale and retail trade	18.3	19.2	19.3	19.1	18.9	19.0	19.2
Finance, insurance, and real estate	3.4	3.8	4.8	5.5	5.9	5.7	5.1
Services	20.9	22.1	23.3	24.9	26.3	28.0	30.0
Public administration	3.9	4.3	5.0	5.6	6.4	7.4	8.5
Industry not reported	2.7	2.6	3.1	3.4	3.2	3.3	3.5
Total, All Industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Table 102.

TABLE 83. PERCENTAGE DISTRIBUTION OF AREA INDUSTRIAL EMPLOYMENT, BY SUBAREAS, 1940-2020

Subarea and Industry	1940	1950	1960	1970	1980	1990	2000	2010	2020
GRAND RAPIDS									
Agriculture, forestry, and fisheries	23.5	24.0	25.6	24.7	22.6	22.5	22.9	22.7	23.0
Mining	70.2	52.2	46.3	46.3	46.8	46.2	46.3	46.3	46.3
Contract construction	44.1	45.0	43.1	42.7	41.6	41.7	41.7	42.0	42.4
Manufacturing	50.1	47.7	46.5	47.4	49.5	50.1	50.5	50.8	51.2
Transportation, communication, and utilities	43.3	44.0	43.8	44.2	43.8	43.9	43.9	44.2	44.7
Wholesale and retail trade	45.9	45.7	45.6	45.8	45.2	45.4	45.4	45.6	46.1
Finance, insurance, and real estate	47.7	47.4	47.1	46.9	46.3	46.4	46.4	46.6	47.0
Services	43.6	41.0	40.1	37.9	35.7	36.3	37.1	38.1	39.2
Public administration	27.9	26.9	27.3	27.1	26.4	26.5	26.5	26.7	27.1
Industry not reported	38.9	33.0	35.4	42.9	38.2	42.5	42.6	42.8	43.3
All Industries	41.9	42.5	42.5	42.6	42.3	42.6	42.6	42.8	43.0
WEST CENTRAL BELT									
Agriculture, forestry, and fisheries	25.2	24.9	23.2	23.6	23.5	23.7	23.6	23.5	23.5
Mining	8.4	16.7	8.0	8.0	7.2	8.1	8.0	8.0	8.0
Contract construction	10.5	9.1	8.5	7.8	7.2	7.1	7.1	7.0	6.8
Manufacturing	7.4	9.1	10.9	11.0	11.1	11.1	11.0	11.1	11.1
Transportation, communication, and utilities	5.7	6.3	5.9	5.7	5.8	5.7	5.7	5.6	5.4
Wholesale and retail trade	7.8	7.9	8.1	8.0	8.0	7.9	7.8	7.7	7.5
Finance, insurance, and real estate	5.4	5.6	5.7	5.6	5.7	5.6	5.6	5.5	5.3
Services	9.5	8.8	7.7	7.7	7.6	7.0	6.7	6.2	5.7
Public administration	7.5	8.6	7.4	7.2	7.0	7.0	6.9	6.8	6.6
Industry not reported	14.8	8.4	11.0	9.0	9.7	8.7	8.6	8.5	8.2
All Industries	11.0	10.1	9.6	9.3	9.1	8.7	8.4	8.1	7.7

TABLE 83. (Continued)

Subarea and Industry	1940	1950	1960	1970	1980	1990	2000	2010	2020
LANSING									
Agriculture, forestry, and fisheries	25.2	25.7	27.8	27.9	28.6	28.3	28.1	28.2	28.1
Mining	5.4	10.5	16.8	16.8	16.8	16.8	16.9	16.8	16.8
Contract construction	27.5	29.3	32.4	34.2	36.4	36.5	36.5	36.5	36.5
Manufacturing	24.5	24.2	21.9	21.0	19.1	18.7	18.5	18.2	18.0
Transportation, communication, and utilities	17.1	19.9	21.7	22.9	23.5	23.9	23.9	23.9	23.9
Wholesale and retail trade	26.0	26.8	27.4	28.0	28.7	28.7	28.7	28.8	28.7
Finance, insurance, and real estate	30.5	33.0	32.3	32.2	32.2	32.3	32.3	32.3	32.3
Services	27.6	32.2	34.7	36.7	38.7	39.3	39.1	39.2	39.1
Public administration	47.4	45.3	47.6	48.0	48.5	48.6	48.6	48.7	48.6
Industry not reported	20.9	39.8	34.7	29.1	32.8	30.2	30.1	30.2	30.2
All Industries	25.9	27.4	28.1	28.7	29.4	29.9	30.4	30.9	31.5
NORTHWEST FRINGE									
Agriculture, forestry, and fisheries	18.3	17.9	15.0	15.4	16.0	16.4	16.5	16.7	16.6
Mining	14.9	15.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Contract construction	7.7	6.8	6.6	6.2	6.0	5.8	5.8	5.6	5.4
Manufacturing	5.7	7.4	8.6	8.8	8.9	8.9	8.9	8.9	8.9
Transportation, communication, and utilities	11.5	10.3	9.8	9.0	9.0	8.5	8.4	8.2	7.9
Wholesale and retail trade	8.0	7.8	7.3	6.8	6.6	6.5	6.5	6.3	6.1
Finance, insurance, and real estate	4.7	4.8	5.3	5.5	5.8	5.6	5.6	5.5	5.3
Services	7.8	7.1	7.1	7.4	7.7	7.1	6.8	6.2	5.7
Public administration	5.2	5.4	5.6	5.6	5.8	5.6	5.6	5.4	5.3
Industry not reported	10.6	7.9	4.9	7.4	7.7	7.0	7.0	6.8	6.6
All Industries	9.2	8.5	8.0	8.0	7.9	7.6	7.4	7.1	6.7

TABLE 83. (Continued)

Subarea and Industry	1940	1950	1960	1970	1980	1990	2000	2010	2020
JACKSON									
Agriculture, forestry, and fisheries	7.8	7.5	8.4	8.4	9.3	9.1	8.9	8.9	8.8
Mining	1.1	4.7	18.9	18.9	19.2	18.9	18.9	18.9	18.9
Contract construction	10.2	9.8	9.4	9.1	8.8	8.9	8.9	8.9	8.9
Manufacturing	12.3	11.6	12.1	11.8	11.4	11.2	11.1	11.0	10.8
Transportation, communication, and utilities	22.4	19.5	18.8	18.2	17.9	18.0	18.1	18.1	18.1
Wholesale and retail trade	12.3	11.8	11.6	11.5	11.5	11.5	11.6	11.6	11.6
Finance, insurance, and real estate	11.7	9.2	9.6	9.8	10.0	10.1	10.1	10.1	10.1
Services	11.5	10.9	10.4	10.3	10.2	10.3	10.3	10.3	10.3
Public administration	12.0	13.8	12.1	12.1	12.3	12.3	12.4	12.4	12.4
Industry not reported	14.8	10.9	14.0	11.6	11.6	11.6	11.7	11.7	11.7
All Industries	11.9	11.5	11.7	11.4	11.3	11.2	11.2	11.1	11.1
AREA									
Agriculture, forestry, and fisheries	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mining	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Contract construction	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Manufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Transportation, communication, and utilities	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Wholesale and retail trade	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Finance, insurance, and real estate	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Services	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Public administration	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Industry not reported	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All Industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 84. COMPOUND ANNUAL GROWTH IN EMPLOYMENT BY INDUSTRY IN THE SUBAREAS, 1960-1980 AND 1960-2020

Industry	Per Cent Annual Growth					
	Area	Grand Rapids	West Central Belt	Lansing	Northeast Fringe	Jackson
				1960-1980		
Agriculture, forestry, and fisheries	-0.8	-1.5	-0.8	-0.7	-0.5	-0.3
Mining	-0.4	-0.3	-0.9	-0.4	-0.4	-0.3
Contract construction	1.5	1.3	0.7	2.1	1.0	1.6
Manufacturing	1.3	1.6	1.4	0.6	1.4	1.3
Transportation, communication, and utilities	0.8	0.8	0.7	1.2	0.4	0.6
Wholesale and retail trade	2.0	1.9	1.9	2.2	1.5	1.9
Finance, insurance, and real estate	3.4	3.4	3.5	3.4	3.9	3.7
Services	2.3	1.7	2.3	2.8	2.7	2.2
Public administration	3.0	2.8	2.8	3.1	3.1	3.1
Industry not reported	2.1	2.5	1.5	1.9	4.4	1.2
All Industries	1.7	1.7	1.5	1.9	1.6	1.5
				1960-2020		
Agriculture, forestry, and fisheries	-0.6	-0.7	-0.5	-0.6	-0.4	-0.5
Mining	0.9	0.9	0.9	0.9	0.9	0.9
Contract construction	1.6	1.6	1.2	1.8	1.3	1.5
Manufacturing	0.9	1.0	0.9	0.6	1.0	0.7
Transportation, communication, and utilities	0.9	1.0	0.8	1.1	0.6	0.9
Wholesale and retail trade	1.6	1.7	1.5	1.7	1.3	1.6
Finance, insurance, and real estate	2.2	2.3	2.1	2.2	2.2	2.3
Services	2.2	2.1	1.7	2.4	1.8	2.2
Public administration	2.9	2.9	2.7	2.9	2.8	2.9
Industry not reported	1.9	2.3	1.5	1.7	2.5	1.6
All Industries	1.6	1.6	1.2	1.8	1.3	1.5

Source: Table 81.

TABLE 85. ADULT POPULATION, LABOR FORCE, AND EMPLOYMENT IN GRAND RAPIDS SUBAREA, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Total Population (14 and Over), thousands	310.9	372.1	441.1	526.1	627.4	746.0	871.3
Labor Force Participation Rate, per cent	56.5	56.6	55.2	54.7	52.9	51.6	51.3
Civilian Labor Force, thousands	175.6	210.6	243.4	288.0	332.2	385.2	447.0
Employment, thousands	166.8	201.1	232.4	276.0	318.6	369.5	428.6
Unemployment, thousands	8.7	9.5	11.0	11.9	13.6	15.7	18.4
Unemployment Rate, per cent	5.0	4.5	4.5	4.1	4.1	4.1	4.1

Sources: 1960 Census of Population, Vol I, Characteristics of the Population, Part 24, Michigan. Battelle projections.

TABLE 86. ADULT POPULATION, LABOR FORCE, AND EMPLOYMENT IN WEST CENTRAL BELT SUBAREA, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Total Population (14 and Over), thousands	76.4	87.8	99.5	113.2	128.5	146.4	163.6
Labor Force Participation Rate, per cent	51.8	52.5	52.5	52.1	51.0	50.0	49.2
Civilian Labor Force, thousands	39.6	46.1	52.2	59.0	65.5	73.2	80.5
Employment, thousands	37.7	44.1	50.1	56.6	63.0	70.3	77.2
Unemployment, thousands	1.9	2.0	2.1	2.4	2.6	3.0	3.3
Unemployment Rate, per cent	4.8	4.3	4.1	4.1	3.9	4.0	4.1

Sources: 1960 Census of Population, Vol I, Characteristics of the Population, Part 24, Michigan. Battelle projections.

TABLE 87. ADULT POPULATION, LABOR FORCE, AND EMPLOYMENT IN LANSING SUBAREA, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Total Population (14 and Over), thousands	205.3	249.1	301.7	363.2	437.1	521.1	608.3
Labor Force Participation Rate, per cent	56.3	56.6	55.8	55.5	53.7	53.0	53.4
Civilian Labor Force, thousands	115.6	141.0	168.2	201.5	234.8	276.2	325.1
Employment, thousands	110.3	135.2	161.6	194.2	226.8	267.0	314.5
Unemployment, thousands	5.3	5.8	6.6	7.3	8.0	9.2	10.6
Unemployment Rate, per cent	4.6	4.1	3.9	3.6	3.4	3.3	3.3

Sources: 1960 Census of Population, Vol I, Characteristics of the Population, Part 24, Michigan. Battelle projections.

TABLE 88. ADULT POPULATION, LABOR FORCE, AND EMPLOYMENT IN NORTHEAST FRINGE SUBAREA, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Total Population (14 and Over), thousands	61.3	70.0	80.6	93.3	107.8	123.7	139.4
Labor Force Participation Rate, per cent	54.6	56.6	56.9	55.5	53.7	51.7	50.5
Civilian Labor Force, thousands	33.4	39.6	45.9	51.8	58.0	64.0	70.4
Employment, thousands	31.5	37.6	43.5	49.1	55.3	61.1	67.1
Unemployment, thousands	2.0	2.0	2.3	2.6	2.6	2.9	3.3
Unemployment Rate, per cent	5.9	5.1	5.1	4.6	4.5	4.5	4.7

Sources: 1960 Census of Population, Vol I, Characteristics of the Population, Part 24, Michigan. Battelle projections.

TABLE 89. ADULT POPULATION, LABOR FORCE, AND EMPLOYMENT IN JACKSON SUBAREA, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Total Population (14 and Over), thousands	91.8	107.4	124.1	148.1	175.7	205.7	237.5
Labor Force Participation Rate, per cent	53.3	53.3	53.0	51.9	50.1	49.4	49.3
Civilian Labor Force, thousands	48.9	57.2	65.7	76.8	88.0	101.6	117.0
Employment, thousands	45.8	53.8	61.9	72.7	83.5	96.3	110.9
Unemployment, thousands	3.1	3.3	3.8	4.1	4.5	5.3	6.1
Unemployment Rate, per cent	6.4	5.8	5.8	5.3	5.1	5.2	5.2

Sources: 1960 Census of Population, Volume I, Characteristics of the Population, Part 24, Michigan. Battelle projections.

TABLE 90. PROJECTED EMPLOYMENT IN SELECTED INDUSTRIES OF THE SUBAREAS, 1960-2020

	1960	1970	1980	1990	2000	2010	2020
Grand Rapids Subarea							
Household furniture	4,900[a]	4,300	4,200	4,500	4,600	4,700	4,700
Office furniture	1,600[a]	3,000	2,900	2,700	2,600	2,300	2,100
Public building furniture	1,600[a]	2,700	2,600	2,400	2,100	2,100	2,100
Cutlery, hand tools, etc.	3,300	3,500	3,100	3,500	3,600	3,800	3,900
Metal stampings	3,800	4,300	4,700	5,000	5,200	5,500	6,000
Metalworking machinery and equipment	3,000	3,000	3,900	4,200	4,700	5,000	5,500
Electrical industrial apparatus	800	1,500	1,900	2,200	2,600	3,000	3,500
Household appliances	(b)	3,000	2,900	2,900	2,800	2,700	2,700
Motor vehicles	1,100	1,100	1,200	1,200	1,200	1,200	1,200
Scientific instruments	4,200	2,700	2,700	2,700	2,700	2,800	2,800
West Central Belt Subarea							
Metalworking machinery and equipment	1,500	1,500	2,000	2,200	2,400	2,600	2,800
Household appliances	(b)	2,500	2,400	2,400	2,400	2,400	2,300
Motor vehicles	3,000	3,000	3,200	3,300	3,300	3,300	3,300
Lansing Subarea							
Miscellaneous primary metals	1,500	1,900	2,000	2,100	2,200	2,200	2,300
Motor vehicles	24,000	24,200	25,600	26,200	26,000	26,200	26,000
Regular state government	7,000[c]	8,600	10,500	12,300	14,200	16,000	17,900
Northeast Fringe Subarea							
Electrical industrial apparatus	1,400	2,700	3,400	4,100	4,700	5,500	6,300
Motor vehicles	2,400	2,400	2,500	2,600	2,600	2,600	2,600
Jackson Subarea							
Tires and Tubes	1,600	1,100	900	800	700	600	500
Motor vehicles	5,600	5,600	5,900	6,100	6,000	6,100	6,000

Note: 1960: U. S. Census of Population: 1960, General Social and Economic Characteristics, Michigan, Tables 61-62, 85.
1970-2020: Battelle projections.

(a) Estimated.

(b) Not available for release.

(c) County report data, Michigan Civil Service Commission.

TABLE 91. INDEX OF VALUE ADDED BY SELECTED INDUSTRIES OF THE SUBAREAS, 1960-2020

(Index Computed on Basis of Constant 1960 Dollars)

Subarea and Industry	Index of Value Added						
	1960	1970	1980	1990	2000	2010	2020
Grand Rapids							
Cutlery, hand tools, and hardware	100.0	137.6	158.5	217.8	283.6	368.9	478.0
Metal stampings	100.0	147.4	205.1	272.2	354.4	461.1	622.4
Household appliances	100.0	241.3	362.0	450.0	548.8	669.9	815.6
Motor vehicles	100.0	119.9	150.9	183.2	216.2	259.8	305.9
West Central Belt							
Household appliances	100.0	241.3	362.0	450.0	548.8	669.8	815.6
Motor vehicles	100.0	119.9	150.9	183.2	216.2	259.8	305.9
Lansing							
Miscellaneous primary metals	100.0	157.3	216.9	279.9	360.9	465.1	597.5
Motor vehicles	100.0	119.9	150.9	183.2	216.2	259.8	305.9
Northeast Fringe							
Motor vehicles	100.0	119.9	150.9	183.2	216.2	259.8	305.9
Jackson							
Tires and inner tubes	100.0	101.3	120.9	133.5	145.4	154.9	160.5
Motor vehicles	100.0	119.9	150.9	183.2	216.2	259.8	305.9

Source: (1970-2020) Battelle estimates and projections.

I-C. BIBLIOGRAPHY

INTRODUCTION

This bibliography is an inventory of available published economic information concerning the Grand River Basin. The emphasis is on economic activities, population, and natural resources, with particular attention given to water-resource development and use within the basin. It represents what is believed to be the best available information. Approximately 5000 references were screened to obtain those cited. The literature search that resulted in this selected, annotated bibliography was undertaken as a part of an economic-base study of the Grand River Basin Service Area. The bibliography has been organized according to the following typical economic-base-study content areas: physical base; population; manufacturing; trade; agriculture; finance, insurance, and real estate; transportation; utilities and communication; extractive industries; public administration; recreation; and water. Within each area the references are listed in alphabetical order by author, if the author is known, or by title if the author is unknown. Because many of the references include information for more than one subject area, each reference is listed according to the subject given the primary emphasis. References that contain a broad range of information without emphasis in a particular area have been grouped under the title "General Sources". A list of references provided by the sponsor was especially helpful in initiating the search; these references are indicated with an asterisk.

The literature references includes journal articles; conference papers; books; county, state, and Federal agency reports, pamphlets, and periodicals; congressional reports; and reports from private industries. When annual or periodically revised publications were selected, usually only the latest editions were referenced. Each such reference actually identifies a series of the same type of publication.

Invaluable assistance in the acquisition of information was provided by Dr. Paul Herbert, Michigan Department of Economic Expansion, and his staff. They made available much information in their possession and recommended other sources of valuable material. Many other persons and organizations also assisted.

Norman Barcus of the Michigan Employment Security Commission provided labor-force information unobtainable from other sources. Dr. Orton Horace Clark of the geography department of the University of Michigan furnished geological maps and geographic information on the eleven-county region. The Soil Conservation Service, United States Department of Agriculture, Michigan State University, under Director Dr. A. J. Collins, supplied county soil surveys, soil-conservation-district programs, and soil maps of Michigan. City and regional planning commissions provided reports based on information they had collected and evaluated. Richard Courter, Grand Rapids City Planning Commission, and Dr. George D. Hurrell, Director of Jackson Metropolitan Area Regional Planning Commission, supplied economic information and gave special assistance in securing further information for their respective areas. Loring F. Oeming, Michigan State Water Resources Commission, furnished many of the references relating to water and sewage problems.

Information has also been collected from the Battelle Economics Library; The Ohio State University Library; the Ohio State Library; the Michigan State Library; W. E. Upjohn Institute for Employment Research, Michigan; and Michigan state departments concerned with banking, conservation, health, revenue, and transportation.

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5. "Barry Soil Conservation District Program of Work", Barry Soil Conservation District, Hastings, Michigan (1963), 19 pp.

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6. "Climatology and Weather Services of the St. Lawrence Seaway and Great Lakes", Technical Paper No. 35, Weather Bureau, U. S. Department of Commerce, Washington, D. C. (1959), 75 pp.

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Analysis of present transportation in Clinton, Eaton, and Ingham Counties and its relationship to long-range planning for the area.

91. "Waterborne Commerce of the United States, 1962, Part 3, Waterways and Harbors, Great Lakes", Department of the Army, Corps of Engineers, Chicago (1963), 245 pp.

Statistics on the waterborne commerce on the Grand River and the harbors of Grand Haven and Holland.

I-48. Utilities and Communication

92. Jones, V. A., North American Radio-TV Station Guide, Howard W. Sams & Company, Inc., Indianapolis, Indiana, and The Bobbs-Merrill Company, Inc., New York (January 1963), 128 pp.

Compilation of broadcast-station information by Michigan cities.

93. Seligman, N., Editor, The Working Press of the Nation/Magazine and Editorial Directory, Vol. II, The National Research Bureau, Inc., Chicago (1963), 612 pp.

Comprehensive directory of service, trade, professional, industrial, agricultural, and consumer magazines.

94. Seligman, N., Editor, The Working Press of the Nation/ Newspaper and Allied Services Directory, Vol. I, The National Research Bureau, Inc., Chicago (1963), 580 pp.

Includes list of principal daily and weekly newspapers published in Michigan.

95. Seligman, N., Editor, The Working Press of the Nation/Radio and Television Directory, Vol. III, The National Research Bureau, Inc., Chicago (1963), 471 pp.

Includes list of all major radio and TV stations, organized by city within the state.

96. "Forty-Second Annual Report of the Federal Power Commission", Federal Power Commission, Washington, D. C. (January 9, 1963), 153 pp.

Includes following information for Michigan and all other states: Identification of steam-electric plants of 700 mw and over and those with heat rates of less than 9500 Btu per net kilowatt-hour; trends of fuel costs in steam-electric plants;

estimates of volume of developed and underdeveloped hydroelectric power; projects under major license; and acreage of land reserved for waterpower purposes.

97. "Hydro Development, 1951, State of Michigan", Hydrology Division, Michigan Water Resources Commission, Lansing (1951).

Physical data by major drainage basins of installed hydroelectric power resources of Michigan.*

98. "Hydroelectric Power Resources of the United States: 1960", Federal Power Commission, Washington, D. C. (August 1961), 209 pp.

Presents compilations and summaries of data as of January 1, 1960, on the resources of the United States for the development of hydroelectric power. The compilations bring together available data on developed and underdeveloped power in individual listings of existing hydroelectric plants and undeveloped power sites. The listings are grouped and arranged by major drainages and river basins and by geographic divisions and states.

99. "Rural Electrification Administration, Report 1961", U. S. Department of Agriculture, Washington, D. C. (December 1961), 34 pp.

Statistics by states of progress of rural electrification and rural telephony.*

I-49. Extractive Industries

100. Carlson, E. T., and Sorenson, H. O., "Michigan Mineral Industries, 1961", Geological Survey Division, Michigan Department of Conservation, Lansing (December 1962), 99 pp.

Compilation of mineral production data for 1961. Includes information on new developments in the field, a summary for each mineral industry, a breakdown of production by counties, and a directory of mineral producers.

101. Klyce, D. F., "The Mineral Industry of Michigan, 1963", chapter from Bureau of Mines Minerals Yearbook, Vol III, U. S. Department of the Interior, Bureau of Mines, Washington 25, D. C.

Itemizes metallic and nonmetallic mineral production for 1962 and 1963. Provides data on production facilities and trends in shipments.

102. "Fish Planting Record, 1962", Division of Fisheries, Michigan Department of Conservation, Lansing (February 1963).

Reports fish plantings by counties; total weight, number, kinds, and sizes of fish.*

103. "Michigan Forest Facts", Michigan Forest Industries Committee, Detroit, and American Forest Products Industries, Inc., Washington 6, D. C. (1959), 15 pp.

Describes forest areas by county. Includes information on tree farms, ownership of forest lands, and wood-use industries.

104. Minerals Yearbook, 1961, Area Reports, Vol. 3, U. S. Department of the Interior, Bureau of Mines, U. S. Government Printing Office, Washington 25, D. C. (1962), 1173 pp.

Contains a review by county of the type and value of mineral production in Michigan.

105. "Summary of Operations, Oil and Gas Fields, 1962", Geological Survey Division, Michigan Department of Conservation, Lansing (May 1963), 44 pp.

Statistics for 1962 by counties and producing fields; also comparative data for years prior to 1962.*

106. U. S. Census of Mineral Industries: 1958, Vol. I, Summary and Industry Statistics, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1961).

Contains state summaries and selected statistics by county.

107. U. S. Census of Mineral Industries: 1958, Vol. II, Area Statistics, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1961).

Contains such statistics as number of establishments; quantity and quality of shipments and receipts; capital expenditures; number of employees, man-hours and payrolls; cost of supplies; fuels; electric energy; contract work; and purchased machinery installed. Figures are shown by industry and by county, and for some industry groups within the county.

108. to 109. U. S. Census of Mineral Industries: 1954, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1958).

Vol. I, Summary and Industry Statistics
Vol. II, Area Statistics

Contain much detail on water usage by the mineral industries.

I-50. Public Administration

110. Press, C., "Selected Bibliography on Michigan Government and Politics", Institute for Community Development, Michigan State University, East Lansing (1963), 12 pp.

111. Census of Governments: 1962, Vol. I, Governmental Organization, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1963), 376 pp.

Provides numbers of governmental units in existence and the nature of local governments authorized in the state as of early 1962.

112. Census of Governments: 1962, Vol. II, Taxable Property Values, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1963), 160 pp.

Presents figures concerning the values that were assessed in 1961 on property subject to local general property taxation; information on real properties that changed hands during a six-month period of 1961; and estimates of the number of pieces of locally assessed real property, and of the distribution of these properties and their assessed values.

113. Compendium of City Government Finances in 1962, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1963), 100 pp.

Annual detailed financial information for individual cities and selected urban towns and townships of over 50,000.

114. "Detail of Capital Outlay Budget for the Fiscal Year Ending June 30, 1964", Michigan Department of Administration, Lansing (1963), 138 pp.

Contains the total capital outlay program of the state. Tables show departmental projects, money requested, and amounts recommended for appropriation.

115. "Financial Report of Michigan County Government, 1961", Auditor of the State, Lansing (1962), 31 pp.

Presents limited detail for individual counties on revenue, expenditure, personal services, debt transactions, capital outlay, and debt outstanding.

116. "Statement of Legislative Appropriations for the Fiscal Year Ending June 30, 1963", Michigan Department of Administration, Lansing (1962), 20 pp.

Tabulates 1961-62 appropriations and 1962-63 recommendations and appropriations for various funds. Summarizes the governor's budget and changes made by the Legislature.

117. "Statement of Long Range Capital Outlay Needs for the Five-Year Period 1963-64 Through 1967-68 as Requested by State Agencies", Michigan Department of Administration, Lansing (January 1963), 101 pp.

Tables show departments, agencies, and groups; the amount requested for 1963-64; projected amounts for the ensuing four years; and the total amount needed for the five-year period.

118. "Twenty-First Annual Report, 1961-1962", Michigan Department of Revenue, Lansing (November 1962), 95 pp.

Describes organization and functions of the Department, defines sources of revenue, and presents the 1962 status of tax legislation.

119. U. S. Census of Governments: 1957, Vol. II, No. 2, Summary of Public Employment, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1958), 931 pp.

Contains selected employment statistics for individual county, municipality, and township governments and for individual school districts enrolling 300 or more pupils.

120. U. S. Census of Governments: 1957, Vol. II, No. 3, Local Government Employment in Standard Metropolitan Areas, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1958), 69 pp.

Brings together figures on employees and payrolls of local governments in standard metropolitan areas, supplying for the

central portions of these areas more detail than is available separately for other local governments from the 1957 Census of Governments.

121. U. S. Census of Governments: 1957, Vol. III, No. 1, Finances of School Districts, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1958), 367 pp.

Presents financial statistics for individual school districts enrolling 300 or more pupils.

122. U. S. Census of Governments: 1957, Vol. III, No. 3, Finances of Municipalities and Township Governments, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1959), 455 pp.

Financial statistics for individual municipalities and township governments.

123. U. S. Census of Governments: 1957, Vol. III, No. 4, Finances of County Governments, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1959), 269 pp.

Financial statistics for individual county governments.

124. U. S. Census of Governments: 1957, Vol. III, No. 6, Local Government Finances in Standard Metropolitan Areas, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1959), 148 pp.

Presents statistics on local government finances in individual standard metropolitan areas.

125. U. S. Census of Governments: 1957, Vol. IV, No. 1, Employee-Retirement Systems of State and Local Governments, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1959), 49 pp.

Presents statistics for individual employee-retirement systems having 200 members or more.

126. U. S. Census of Governments: 1957, Vol. VI, No. 20, Government in Michigan, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1959), 88 pp.

Presents statistics on the organization, employment, and finances of the state and local governments.

I-51. Recreation

127. Weber, E. W., "Recreation as a Purpose of Water Resource Development", U. S. Army Corps of Engineers, Washington, D. C. (May 1962), 22 pp.

Outlines history of recreational development and relationship to project planning.*

128. "Area and Ownership of State and Federal Forests and Recreation Lands", Lands Division, Michigan Department of Conservation, Lansing (May 1962), 2 pp.

Area owned by Michigan and Federal Agencies according to state regions.

129. "List of Public Outdoor Recreation Areas 1960", Outdoor Recreation Resources Review Commission, Washington, D. C. (1962), 173 pp.

Management agency, acreage, and county location of nonurban public recreation areas.

130. "Michigan Campground Directory", Michigan Department of Conservation, Lansing (May 1963), 16 pp.

Lists state park campgrounds, state and national forest campgrounds, and county and local parks.

131. "Michigan Outdoor Guide", Touring Department Automobile Club of Michigan, Detroit (1962), 49 pp.

Brochure describing parks, forests, and campgrounds and associated facilities.

132. "Michigan's Recreation Future", Proceedings of the Seventh Annual Conference, Michigan Natural Resources Council, Lansing (October 24, 1962), 78 pp.

Summary of findings of Outdoor Recreational Resources Review Commission. General discussions of state needs and resources and recreational programs of other states. Guidelines for recreational planning.

133. "Michigan's Resources for Outdoor Recreation", Proceedings of the Michigan Natural Resources Council Annual Meeting, Lansing (October 28, 1959), 53 pp.

Eight papers giving a general description of Michigan's geographic characteristics as a basic resource for outdoor recreation, identification of socio-economic conditions that are destroying or limiting the potential of Michigan's recreational resources and recommendations for remedial action, and current Michigan studies and projects in outdoor recreation.

134. "Outdoor Recreation, an Inventory", Tri-County Regional Planning Commission, Lansing, Michigan (January 1962), 51 pp.

Describes facilities, the primary purpose of which is recreation. Major types of recreation are discussed generally, and maps of Clinton, Eaton, and Ingham counties locate the facilities (description based upon a preliminary draft of the report).

135. "Recreation and Park Yearbook, 1961", National Recreation Association, New York (1961).

Statistics on recreational areas and their management authority, acreage, employees, and expenditures.

136. "Report of Committee on State Parks and Public Lands", Interim Committee, House of Representatives, U. S. Government Printing Office, Washington 25, D. C. (1963), 22 pp.

Surveys attendance, park uses, operation and maintenance, revenues, and expansion needs. Makes recommendations to the Departments of Conservation, Administration, and Highways and to the State Legislature for improving parks and recreational facilities.

I-52. Water

Municipal Water Supply

137. Milliman, J. W., "Policy Horizons for Future Urban Water Supply", Resources for the Future, Inc., Washington, D. C., and Indiana University, Bloomington (December 1962).

Discusses present status of urban water economics, some future problems, and aspects of policy making on water supply, use, and pricing.

138. "Data on Public Water Supplies in Michigan", No. 4, Michigan Department of Health, Lansing (1961), 57 pp.

Tabulates counties, municipalities, population sources, treatment, storage capacities, and chemical analyses.

139. "Municipal Water Facilities, Communities of 25,000 Population and Over, as of January 1, 1962", Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. (1962), 108 pp.

140. "Municipal Water Facilities, Inventory as of January 1, 1958", Vol. 5, U. S. Department of Health, Education and Welfare, Public Health Service, Division of Water Supply and Pollution Control, Washington, D. C. (January 1, 1958), 140 pp.

Covers Illinois, Indiana, Michigan, Ohio, and Wisconsin. Gives names of communities, population, source of supply, treatment characteristics, and other data.

Sewage Treatment

141. "Directory of Sewage Treatment Plants and Superintendents", Division of Engineering, Michigan Department of Health, Lansing (March 1961), 17 pp.

Lists locations, population, classes and types of sewage treatment, and names of superintendents.

142. Waste Water Disposal Practices at Federal Installations as of December 31, 1960, Vol. XXIII, Michigan, U. S. Department of Health, Education and Welfare, Public Health Service, Division of Water Supply and Pollution Control, Washington 25, D. C. (1962), 50 pp.

An inventory of waste-water disposal practices of Federal activities on real property owned by or leased to the Federal Government.

Flood Control

143. Pfeil, R. C., "Survey Report on Grand River Basin, Michigan--Interim Report on Flood Control at Granville", U. S. Army Engineer District, Detroit Corps of Engineers, Detroit (March 7, 1962), 22 pp.

Survey data leading to recommendations for construction of levees and other flood-control measures along Buck Creek, Highway I-96, and nearby locations.

144. "Flood Conditions in the Lansing Area", Michigan Water Resources Commission, Lansing (September 1954), 12 pp.

Flood history, causes, and methods of control and prediction.

145. "Grand River at Lansing, Michigan", No. 132, Senate, Eighty-Fourth Congress, Second Session, U. S. Government Printing Office, Washington 25, D. C. (1956), 43 pp.

A review by the Corps of Engineers of a 1947 congressional report on Grand River, Michigan with particular reference to flood control.

146. "Regional Flood Frequency Study, Grand River Drainage Basin", U. S. Army Corps of Engineers, Detroit (February 1962), 9 pp.

Statistical flood-frequency analysis based on correlation and regression procedures.*

147. "Report on Dams and Other Obstructions in Lakes and Streams", Fisheries Division, Michigan Department of Conservation, Lansing (1953).

Presents by counties, the name, stream basin, location by sec-twp-range, head in feet, date of construction, and ownership of dams.*

148. "Supplemented Report of the Grand River to the 1958 Survey Report on Major and Local Drainage for Portage River, Michigan", U. S. Department of Agriculture, Soil Conservation Service, Milwaukee, Wisconsin (July 1959), 19 pp.

Determines agricultural benefits and reduction of flood-water damage on land adjacent to the Grand River if improvements were made to the river channel.

149. "Survey Report for Major and Local Drainage for Lookingglass River, Michigan", U. S. Department of Agriculture, Soil Conservation Service (June 1961), 31 pp.

Presents a project of local drainage improvements, estimates the cost of the improvements, and evaluates the agricultural drainage benefits and reduction of flood-water damages that would result.

150. "Survey Report for Major and Local Drainage for Portage River, Michigan", U. S. Department of Agriculture, Soil Conservation Service, Milwaukee, Wisconsin (July 1958), 35 pp.

Determines the effect of an improvement of the Portage River upon local drainage facilities. Evaluates the effects of river and local drainage improvements on agriculture.

151. "Survey Report on Major and Local Drainage for Stoney Creek, Michigan", U. S. Department of Agriculture, Soil Conservation Service, Milwaukee, Wisconsin (June 1960), 27 pp.

Presents a program of local drainage improvements, estimates the cost of those improvements, and evaluates the agricultural benefits which would result.

152. "Watershed Work Plan, Muskrat Creek Watershed, Clinton County, Michigan", Clinton County Soil Conservation District, Morris Drain Drainage District (October 1959), 15 pp.

Discusses the watershed and its problems. Describes land treatment and structural measures, benefits and costs, provisions for financing construction, and operation and maintenance procedures.

Planning

153. Laberge, R. H., "Water Resources Background Facts, Grand River Basin, Michigan", School of Public Health, University of Michigan, Ann Arbor (May 1958), 37 pp.

Covers hydrology, community and industrial development, river characteristics, and agencies affecting water resources.

154. Langworthy, V. W., "The Water Utility and Regional Planning", Water and Sewage Works, Vol. 110, No. 3, March 1963, pp. 100-101.

Reviews the major aspects of regional planning and indicates the area where the water utility can and should play an active part. An area in central Michigan which has a regional planning commission is examined.

155. Schmid, A. A., "Michigan Water Use and Development Problems", Agricultural Experiment Station, Department of Agricultural Economics, Michigan State University, East Lansing (1961), 30 pp.

Discusses water use conflicts in agriculture and municipalities, problems between irrigators and other users, waste-disposal conflicts, lake levels, and artificial-lake construction.

156. "Alternative Long-Range Water Use Plans for the Tri-County Region, Michigan", Report from Battelle Memorial Institute, Columbus, Ohio, to the Tri-County Regional Planning Commission (1963).

Reports development and appraisal of alternative plans for meeting water needs of Eaton, Clinton, and Ingham Counties to the year 2000, with emphasis on the ten-township core of the region.

157. "River Basin Planning, Great Lakes--St. Lawrence Drainage Basin, Detroit District", U. S. Army Corps of Engineers, Detroit (September 1961), 87 pp.

Presents discussion on planning of water resource; includes maps outlining limits of drainage basins.

Water Law

158. Adams, M. P., et al., "Michigan's Water Resources Problems and Future Legislative Needs", Michigan Water Resources Commission, Lansing (January 22, 1959), 24 pp.

Gives data on the Great Lakes and other supply sources and their present uses for recreation, power, municipal and industrial purposes, and irrigation. Recommends appointment of a Special Study Commission to determine needed legislative remedies.

159. "Papers Delivered at the Water Rights Conference", College of Agriculture, Water Resources Committee, Michigan State University, East Lansing (March 29, 1960), 77 pp.

Papers discuss federal jurisdiction over water in the eastern United States, riparian doctrine with reference to the eastern states, Wisconsin's experience in writing a water law, Iowa's water law, and interpretation and current status of ground water rights.

Water Quality and Pollution

160. Kneese, A. U., "The Economics of Regional Water Quality Management", Resources for the Future, Inc. (January 1963), 235 pp.

Describes the effects of water pollution and methods of treatment and abatement. Discusses the economic allocation theory relevant to waste-disposal problems. Indicates economic design criteria for a basin-wide waste-disposal system. Outlines the application of economic principles to the operation of regional waste disposal systems.

161. "Conference, City of Lansing, Michigan Water Resources Commission", Michigan Water Resources Commission, Lansing (September 26, 1963), 12 pp.

The regulation of flow of the Grand River in relation to the sewage treatment needs of the city of Lansing is discussed.

162. "Final Orders of Determination--Municipal", Michigan Water Resources Commission, Lansing (August 31, 1963), 3 pp.

Gives names of municipalities, status, and dates of order, abatement, and extension.

163. "Industrial Pollution Status", Michigan Water Resources Commission, Lansing (April 1, 1963), 24 pp.

Evaluates pollution control exercised by specific industrial facilities.

164. "Municipal and Industrial Waste Facilities, 1957 Inventory, Region V, Illinois, Indiana, Michigan, Ohio and Wisconsin", Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. (1958), 340 pp.

Inventory of data for sources of pollution, both municipal and industrial, by alphabetical sequence of names of communities.*

165. "Municipal and Industrial Waste Facilities, 1957 Inventory, Region V", Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. (1959), 66 pp.

Contains the latest available data for all sources of pollution, both municipal and industrial, which are of significance in water pollution control programs.

166. to 168. "Orders of Determination--Industrial", Michigan Water Resources Commission, Lansing.
"Final Orders" (August 31, 1962), 5 pp.
"Industrial/Inactive for Reasons Indicated" (August 31, 1962), 8 pp.
"New or Increased Use" (August 31, 1962), 18 pp.

Identifies industries contributing to water pollution, date of adoption of order, effective date of restrictions, public waters affected, and status.

169. "Oxygen Relationships of Grand River, Lansing to Grand Ledge, 1960 Survey", Michigan Water Resources Commission, Lansing (May 1962), 51 pp.

Analysis of self-purification capacity.

170. "Project Register. Projects Approved Under Section 6 (Public Law 660, 84th Congress) of the Federal Water Pollution Control Act, as Amended and Section 3 (Public Law 658, 87th Congress) of the Public Works Acceleration Act", Public Health Service, U. S. Department of Health, Education and Welfare, Washington 25, D. C. (1962).

Monthly publication listing projects by states and location within each state; also quarterly summaries.

Ground Water Resources

171. Giroux, P. R., "Summary of Ground-Water Conditions in Michigan, 1961", U. S. Geological Survey, U. S. Department of Interior, Washington, D. C., and Geological Survey Division of the Michigan Department of Conservation, Lansing (1962), 98 pp.

Covers ground-water problems and conditions, and state-wide changes in storage from natural and pumping influences.

172. Laird, L. B., Stramel, G. J., and Wisler, C. O., "Water Resources of the Grand Rapids Area, Michigan", U. S. Geological Survey, U. S. Department of the Interior, Washington, D. C. (1954), 40 pp.

Hydrologic data on surface-water and ground-water resources; geology; water supplies, including public, industrial, commercial, and rural; and water law.*

173. Stuart, W. T., "Ground Water Resources of the Lansing Area, Michigan", Geological Survey Division, Department of Conservation, Lansing (June 1945), 33 pp.

Describes drawdown, cone of depression, reinfiltration, and past ground-water usage.

174. "Proposed Four-Year Program of Investigations of the Ground Water Resources in the Upper Grand River Basin, Michigan", Ground Water Branch, Geological Survey, U. S. Department of the Interior, Lansing (January 1959), 17 pp.

Describes proposed geologic, hydrologic, and geochemical investigations and observation studies.

Hydrology

175. Ash, A. D., Eichmeier, A. H., Granger, D. W., Kidder, E. H., et al., "Hydrologic Studies of Small Watersheds in Agricultural Areas of Southern Michigan, No. 1, Deer-Sloan Basin", Michigan Water Resources Commission, Lansing (June 1958), 77 pp.

Basin physiography and analysis of rainfall, runoff, and sedimentation.

176. Eichmeier, A. H., and Wheaton, F. Z., "Hydrologic Studies of Small Watersheds in Agricultural Areas of Southern Michigan, No. 2, Deer-Sloan Basin, Precipitation Studies, 1956-59", Michigan Water Resources Commission, Lansing (August 1960), 73 pp.

Detailed study based on a dense gage network.

177. Gannon, J. J., and Velz, C. J., "Drought Flow Characteristics of Michigan Streams", Michigan Water Resources Commission, Lansing (June 1960), 771 pp.

Compilation of available low-flow records and analyses of precipitation and temperature and of the levels of the Great Lakes bordering the state.

178. Green, R. F., and Humphrys, C. R., "Michigan's Artificial Surface Water", No. 12, Department of Resource Development, Michigan State University, East Lansing (1962), 33 pp.

Tabulates locations and sizes of lakes, ponds, hydroelectric reservoirs, fish and wildlife floodings, municipal and industrial water supply reservoirs, gravel pits and quarries, fish hatcheries and research stations, underwater borrow pits, and other sources of water.

179. "Principal Federal Sources of Hydrological Data", Interagency Committee on Water Resources, U. S. Geological Survey, Department of the Interior, Washington, D. C. (July 1956), 139 pp.

Source data by bureaus and departments, of experimental-station records in 37 states.*

General Information

180. Duke, R. D., and Nickel, P., "An Annotated Bibliography on Water Problems", Institute for Community Development, Michigan State University, East Lansing (July 1962), 23 pp.

Covers policy and administration, organization, research, basin planning, economic analysis, land planning, and legal aspects; also covers other bibliographies.

181. Hirshleifer, J., DeHaven, J. C., Milliman, J. W., "Water Supply: Economics, Technology, and Policy", University of Chicago Press (1960), 378 pp.

Two techniques are contrasted for meeting water demands: improvement in allocation of existing water supplies and development of additional supplies.

182. "County Water Resources Data, Michigan", Michigan Water Resources Commission, Lansing (May 1959).

Hydrologic, construction, recreational, and weather-bureau data by counties.*

183. "Federal Programs for Collection of Data on Water Use", Interagency Committee on Water Resources, Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. (1959), 43 pp.

Source data on water resources, water use, water pollution, water power, navigation, and fish and other wildlife.*

184. "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources", No. 97, The President's Water Resources Council, Eighty-Seventh Congress, Second Session, Washington, D. C. (May 29, 1962), 13 pp.

185. "Water Resource Conditions and Uses in the Upper Grand River Basin", Michigan Water Resources Commission, Lansing (1961), 137 pp.

Discusses characteristics of the basin, hydrology, water use, floods and flood control, low-flow augmentation, and land and water-management problems.

186. "Water Resources Activities in the United States", Index for Committee Prints Nos. 1-32, Senate Select Committee on National Water Resources, Eighty-Sixth Congress (December 1960), 47 pp.

187. "Water Resources Investigations in Michigan", Water Resources Division, U. S. Geological Survey, Washington 25, D. C. (May 1962), 5 pp.

Map showing streamflow stations, inland lake stations, observation wells, quality of water-collection sites, and projects active in 1962; summarizing report and selected references from U. S. Geological Survey.

STATISTICAL

188. Beeson, J., Garrison, A. C., Verway, D. I., Waite, E. B., and Bowlby, R. L., "Michigan Economic Charts", Bureau of Business and Economic Research, Graduate School of Business Administration, Michigan State University, East Lansing (1962), 95 pp.

Graphic presentation of data from Michigan Statistical Abstract.

189. Verway, D. I., Compiler, "Michigan Statistical Abstract", Bureau of Business and Economic Research, Graduate School of Business Administration, Michigan State University, East Lansing (1962), 332 pp.

A wide range of information about Michigan, its counties, cities, and metropolitan areas. Covers population, climate, land area, agriculture, mining, housing, manufacturing, trade, finance and insurance, communication, transportation, public utilities, and services.

190. County and City Data Book, 1962 (A Statistical Abstract Supplement), U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1962), 669 pp.

Contains 161 items of economic, social, and political statistical data for each county in the United States, and 163 items for each city having 25,000 or more inhabitants in 1960.

191. County Business Patterns, First Quarter 1962, Part 4A, East North Central States (Michigan, Wisconsin), U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1963).

Presents employment and payroll statistics for industry groups reported under the Federal Insurance Contributions Act, by counties and standard metropolitan statistical areas.

192. to 202. "Economic Data Sheets" with Agricultural and Labor Supplements, Michigan Economic Development Department, Research Division.

Barry County (November 1961), 8 pp.
Clinton County (November 1961), 8 pp.
Eaton County (October 1961), 9 pp.
Gratiot County (November 1961), 9 pp.
Ingham County (October 1961), 10 pp.
Ionia County (November 1961), 9 pp.
Jackson County (December 1961), 11 pp.
Kent County (November 1961), 12 pp.
Montcalm County (November 1961), 8 pp.
Ottawa County (November 1961), 12 pp.
Shiawassee County (November 1961), 10 pp.

Tables show land area, population, income and bank deposits, health facilities, utilities and water supplies, business and manufacturing establishments, dollar values of retail trade and selected services, agricultural and mineral data, transportation facilities, occupational employment, and climate.

203. "Employment and Earnings", U. S. Department of Labor, Bureau of Labor Statistics, Washington, D. C.

Statistics on labor force, payroll employment, and labor turnover collected and tabulated monthly.

204. "Employment and Earnings Statistics for States and Areas, 1939-62", Bureau of Labor Statistics, U. S. Department of Labor, Washington 25, D. C. (1963), 633 pp.

Provides detailed information for the state and its major areas on the employment, hours, and earnings of nonfarm workers.

205. "Labor Force and Employment Estimates", Michigan Employment Security Commission, 1958-1962.

Monthly Estimates for six counties in the study area according to two-digit S. I. C. industry groups.

206. "Michigan Labor Market Letter", Michigan Employment Security Commission.

Two-page summary of labor force totals for state and for Detroit by two-digit S. I. C. industry groups.

207. Michigan Manual/1961-1962, State of Michigan (1962), 714 pp.

Contains chronology of Michigan history, lists of Michigan newspapers, radio and television stations.

208. Statistical Abstract of the United States: 1963, Eighty-Fourth Edition, U. S. Bureau of the Census, U. S. Government Printing Office, Washington 25, D. C. (1963), 1036 pp.

Summarizes current social, political, and economic statistics for the United States as a whole and to a lesser extent for regions, divisions, and states and for historical series.

I-55. Interpretive

209. Bald, F. C., Michigan in Four Centuries, Harper, New York (1961), 481 pp.

210. Beale, C. L., and Bogue, D. J., Economic Areas of the United States, The Free Press of Glencoe, Inc., New York (1961), 1350 pp.

A comprehensive statistical and descriptive analysis of socio-economic characteristics.

211. Cox, E. P., Henderson, J. P., Henshaw, R. C., and O'Donnell, J. L., "Economic and Population Base Study of the Lansing Tri-County Area", Bureau of Business and Economic Research, College of Business and Public Service, Michigan State University, East Lansing (1960), 319 pp.

Area history; past and current population, labor force, and income distribution; forecasts of population, labor force, and income developed from input-output matrix.

212. Dean, M. H., Editor, "Overall Economic Development Program, 1962, Gratiot County, Michigan", Gratiot County Over-All Economic Development Committee (July 25, 1962), 24 pp.

Describes economic characteristics of the redevelopment area and their relationship to potential growth.

213. Fuller, G. N., Economic and Social Beginnings of Michigan, Lansing (1916), 630 pp.

214. Haber, W., McKean, E. C., and Taylor, H. C., The Michigan Economy, Its Potentials and Its Problems, The W. E. Upjohn Institute for Employment Research, Kalamazoo, Michigan (1959), 395 pp.

This publication discusses the structure of Michigan's economy, including an evaluation of performance by industry sectors.

215. Haber, William, Spivey, W. Allen, Warshaw, Martin R., Editors, Michigan In The 1970's, An Economic Forecast, Bureau of Business Research, Ann Arbor, Michigan, Michigan Business Studies, Volume 16, No. 4, 1965.

Analysis of employment problems and automotive and other industrial and economic trends. Projections of population and employment.

216. Hudgins, B., Michigan Geographic Backgrounds in the Development of the Commonwealth, Edwards Brothers, Inc., Ann Arbor, Michigan (1961), 116 pp.

Background information on Michigan's physical setting, geology, climate, history, and commercial and industrial activities.

217. Lund, R. J., "The Future of the Great Lakes States Area Versus Other Geographical Areas", Battelle Memorial Institute, Columbus, Ohio (1959), 27 pp.

A paper presented to the 7th Annual Conference, Great Lakes States Industrial Development Council, Ann Arbor, Michigan, January 14-16, 1959. Compares population, labor force characteristics, resources, and value added by manufacture.

218. Suggitt, F. W., "For the Future of Ottawa County", Ottawa County Planning Study Committee, Grand Haven, Michigan (October 1957), 21 pp.

Analyzes population, agricultural, and industrial trends in Michigan and Ottawa County; recommends formation of a county planning Commission.*

219. "Central Business District Study of Lansing, Michigan", J. & G. Daverman Company, Grand Rapids, Michigan (June 1960), 110 pp.

A plan for refashioning the downtown area to meet present and future needs.

220. "Comprehensive Master Plan, Lansing and Environs, 1960-80", Lansing City Planning Board, Lansing, Michigan (1960), 233 pp.

221. County Maps, Southern Lower Peninsula, Region III, Michigan Department of Conservation (1961).

Maps show basic geographic features, all types of roads, federal--and state-owned lands, and public recreational facilities.

222. "Data on Jackson, Michigan", Area Development Department, Consummers Power Company, Jackson (October 1962), sections individually paged.

A promotion piece for industry. Covers population, employment, industries, earning levels, labor organization and relations, freight and passenger transportation, utilities, local services, taxes, and site data.

223. 1963 Dun and Bradstreet Million Dollar Directory, Dun and Bradstreet, Inc., New York (1962), 4986 pp.

Lists U. S. Business enterprises with an indicated worth of a million dollars and over classified by product, alphabetically, and geographically. Contains statistics on sales, employees, management, and Standard Industrial Classification code.

224. Dun & Bradstreet Reference Book, 1963, Dun and Bradstreet, Inc., New York (1963), 4524 pp.

A directory of businesses organized geographically showing Standard Industrial Classification code and financial ratings.

225. "Grand Rapids Master Plan", City Planning Commission, Grand Rapids, Michigan (1962), 177 pp.

A comprehensive development plan for Grand Rapids utilizing data collected for 16 years on various phases of community development--residential, commercial, industrial, and public. Its basic elements are a land-use plan, circulation plan, community facilities plan, and utilities plan. A planning commission study of shopping centers, their problems and possible solutions is included.

226. "Manpower in Michigan--A Reappraisal of the 1960's", Michigan Employment Security Commission, Detroit (September 1964), 28 pp.

Forecasts changes in population, makeup of the labor force, job opportunities, unemployment, and school enrollments and dropouts.

227. "The Michigan Yearbook, 1962", Vol. IV, Democratic Business and Professional Committee of Michigan.

Popular presentation of significant activities in the state. Reflects economic, social, and cultural interests.

228. "Private Trade Schools, Business Schools, and Institutes", Michigan Department of Public Instruction, Lansing (1963), 19 pp.

A directory of resident or correspondence schools, in Michigan and out-of-state, licensed by the Department of Public Instruction.

229. "Today and Tomorrow in the Lansing Metropolitan Area", The League of Women Voters of the Lansing Area, Lansing, Michigan (February 1961), 71 pp.

Reports the structure and functions of Meridian Township, East Lansing's Council-Manager type of city government, Lansing's Council-Mayor type of government, Ingham County, and the school districts within these units.

PART II

ELECTRIC ENERGY PRODUCTION AND REQUIREMENTS

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B	Energy Production: Historical and Projected	Federal Power Commission	II-10

ELECTRIC ENERGY PRODUCTION AND REQUIREMENTS

Introduction

This report contains historical data regarding energy requirements and production in the Grand River Basin Service Area (hereafter referred to as the "Area"), and also projections of likely future levels of requirements and production in the Area. The source of all of the data and projections is the Chicago Regional Office of the Federal Power Commission.

The eleven-county Area has been divided into five subareas: the Grand Rapids subarea (Kent and Ottawa counties); the West Central subarea (Barry, Ionia, and Montcalm counties); the Lansing subarea (Clinton, Eaton, and Ingham counties); the Northeast subarea (Gratiot and Shiawassee counties); and the Jackson subarea (Jackson county). Throughout the report, data are presented on a subarea basis.

Section A - Energy Requirements: Historical and Projected

Historical Data. The electrical energy requirements (for meeting loads in all systems) and peak loads for the subareas, Service Area, Michigan, and the United States are shown in table 1. With total requirements of 4.15 billion kilowatt-hours in 1960, the Area represented 14.3 percent of Michigan's total and 0.55 percent of the Nation's. The percentage increase in the Area's power requirements in the decade 1940-1950 (115 percent) was less than Michigan's increase (119 percent) and less than the Nation's (135 percent), whereas its 1950-1960 percentage increase (108 percent) was more than Michigan's (89 percent) and less than the Nation's (123 percent). Energy requirements throughout the two decades were heavily concentrated in the Grand Rapids and Lansing subareas.

Projections. The projections of the Area's power requirements made by the Federal Power Commission are based on national and regional projections made recently in connection with the Commission's National Power Survey.* In making the projections, the Commission was assisted by an Advisory Committee, members of which represented the electric power industry and were appointed by Joseph C. Swidler, Chairman of the Commission. The Advisory Committee was chaired by Earl Wilde, of the Commonwealth Edison Company of Chicago.

The Commission's staff had previously prepared estimates of load and annual energy requirements for the years 1965, 1970, 1975, and 1980. These forecasts had been developed by the Regional Offices along guidelines laid down by the Commission's Washington staff. The Advisory Committee reviewed these forecasts not only as to the premises on which they were based but also in comparison with various long-range regional and national forecasts made by the power suppliers.

*National Power Survey. A Report by the Federal Power Commission in 1964.

Table 1

ELECTRIC UTILITY ENERGY REQUIREMENTS AND PEAK LOADS IN THE SUBAREAS, SERVICE AREA, MICHIGAN AND THE UNITED STATES, 1940, 1950, AND 1960

SUBAREA	Energy Requirements, million kwhr			Peak Loads, thousand kw			Percent Increase			
							Energy Requirements		Peak Loads	
	1940	1950	1960	1940	1950	1960	1940-1950	1950-1960	1940-1950	1950-1960
Grand Rapids	425	910	1,908	85	180	345	114.1	109.7	111.8	91.7
West Central Belt	45	115	255	15	18	58	155.6	121.7	20.0	222.2
Lansing	290	610	1,235	60	117	220	110.3	102.5	95.0	88.0
Northeast Fringe	40	95	207	12	15	47	137.5	117.9	25.0	213.3
Jackson	130	270	545	28	55	100	107.7	101.9	96.4	81.8
Total Service Area	930	2,000	4,150	200	385	770	115.1	107.5	92.5	100.0
Michigan	7,000	15,316	29,000	1,725	2,950	5,520	118.8	89.3	71.0	87.1
United States	144,985	341,073	761,380	N.A.	64,135	137,976	135.2	123.2	N.A.	115.1

Source: Compiled by the Federal Power Commission, Regional Office, Chicago, Illinois, 1964

The estimates adopted for the National Power Survey are not intended to be precise forecasts for any of the five-year points to 1980, but rather to be broad indicators of the likely magnitude of future load growth. Any variation of actual loads in 1965 from those forecasted for 1965 would be significant only to the extent that careful analysis of the derivation indicated a clear shift in long-range influences on power requirements. The assumptions basic to the forecasts are that the Nation's population in 1980 will be 265 million and the rate of growth of gross national product will be 4 percent per year. Electric utility energy requirements for the United States, as estimated by the National Power Survey report, would increase from 761.380 billion kilowatt-hours in 1960 to 2692.650 billion kilowatt-hours in 1980. The peak capacity required would increase from 137.976 million kilowatts in 1960 to 494.231 million kilowatts in 1980.

One of the regular functions of the Regional Offices of the Federal Power Commission is to make regional studies (power market studies) which include estimates of future power requirements and supply. The estimates are made on a power supply area basis in order to facilitate study of the various factors which influence future requirements for electric power. Power supply area boundaries do not correspond with state lines but are governed by the existing integrated service areas of substantially-interconnected utility systems.

The Basin Service Area is located entirely within Power Supply Area 11, which covers all the lower peninsula of Michigan except the southwest corner. (See figure 1).

General factors distinguishing a particular power supply area include such basic characteristics as its location in the Nation, its topographic and climatic characteristics, economic activities, income, and its people. All these factors, including the area's past history and potentialities are considered as they affect the growth of the area's future electric power requirements.

Each category of electric power use (farm use, nonfarm residential use, commercial use, industrial use, and other uses and losses) is studied and analyzed and extended into the future.

Farm use includes farm residential and farm power use. To determine farm power use, the types of farms (such as dairy farms, livestock farms, general farms, and so forth) are studied to determine the electric energy required to operate power equipment common to each type of farm. Residential use is, of course, dependent upon household equipment requirements.

Nonfarm residential use is based upon the requirements of household electrical equipment. The number of households is taken from the Census of Population and projected into the future. Similarly, the average annual use per household is projected into the future.

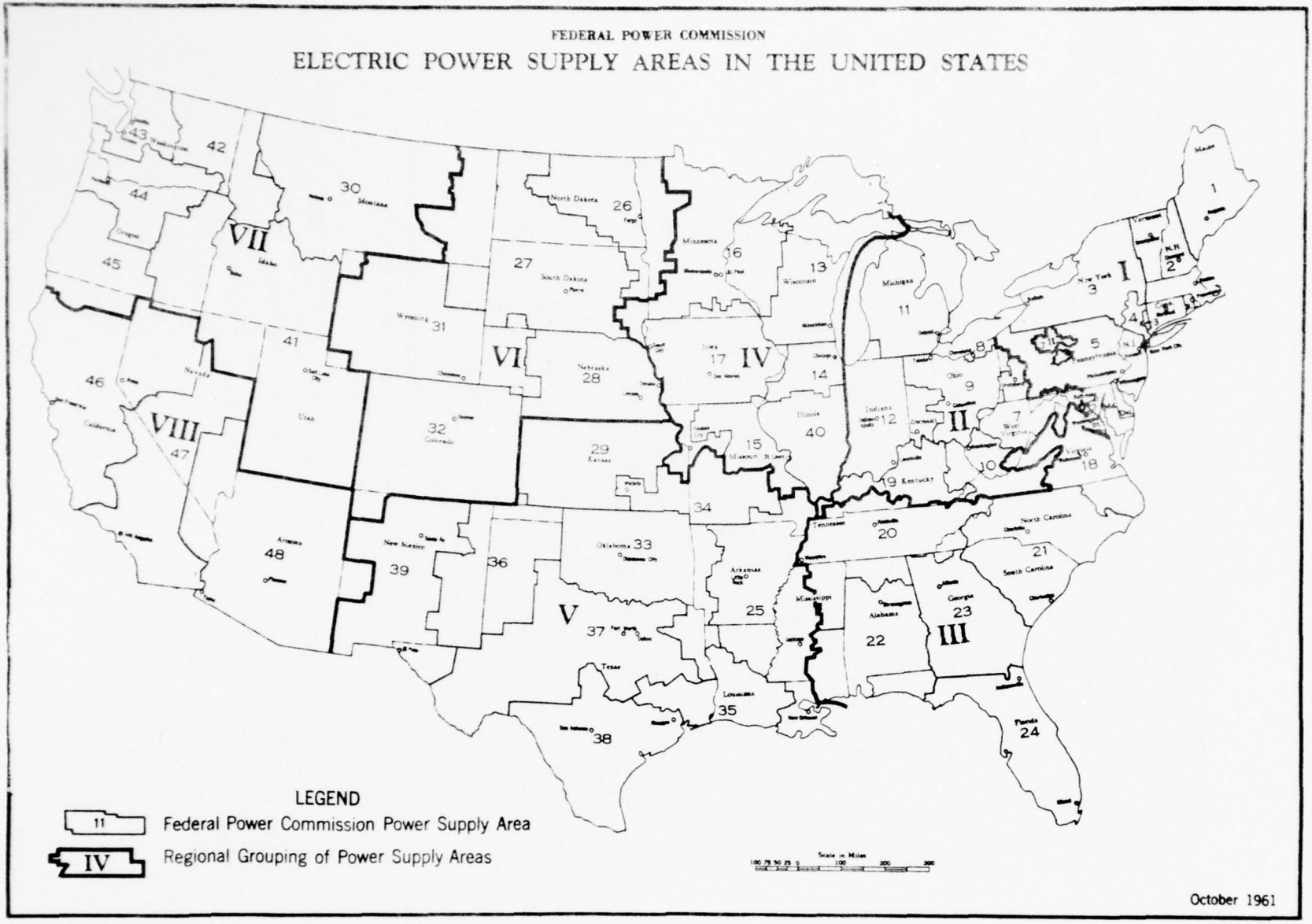
FEDERAL POWER COMMISSION
ELECTRIC POWER SUPPLY AREAS IN THE UNITED STATES
I
II
III
IV
V
VI
VII
VIII
LEGEND
11
Federal Power Commission Power Supply Area
IV
Regional Grouping of Power Supply Areas
October 1961

Figure 1

The number of commercial customers is a function of population. Analysis is made of past trends regarding the number of people per commercial customer in the area. This is dependent upon per capita income and other economic features of the area.

The total electric energy used by industrial plants in the area is measured by purchases from electric utilities, plus industrial generation for direct consumption. In order to project industrial electric energy requirements into the future, each manufacturing and mining category is examined for potentialities, taking into consideration the increasing use of electricity per unit of industrial production and per industrial worker. Possible new industries which would utilize natural resources of the area are also considered.

Energy use for street and highway lighting, municipal services, electrified transportation, and uses not elsewhere classified are designated as other sales. This classification has been studied primarily on the basis of use per capita of the nonfarm population.

The losses incurred in transmitting and distributing power are a function of the location of generators relative to the load and to the density of the load.

After arriving at estimates of electric energy consumption, the probable maximum rate of use must be determined. This rate depends on variations in hourly demands during the day, month and year, and may be expressed in terms of load factors. Monthly and annual demand and load factors reported to the Federal Power Commission are analyzed to determine trends and local characteristics. Using the annual load factor for the total annual use, the annual peak demand is obtained.

Table 2 contains projections of electric utility energy requirements and peak loads for the United States and for Power Supply Area 11.

Table 2

ELECTRIC UTILITY ENERGY REQUIREMENTS AND PEAK LOADS
IN THE UNITED STATES AND IN POWER SUPPLY AREA 11
(Energy in Million KWH, Peaks in Thousand KV)

	United States		Power Supply Area 11	
Year	Energy	Peak	Energy	Peak
1960	761,380	137,976	27,683	5,170
1961	797,362	144,528	28,263	5,341
1965	1,062,160	193,719	35,100	6,610
1970	1,483,750	270,619	46,100	8,560
1975	2,023,890	370,407	59,500	10,900
1980	2,692,650	494,231	77,100	13,900

Table 3

GRAND RIVER BASIN, MICHIGAN ELECTRIC POWER REQUIREMENTS

ENERGY IN MILLION KWH PEAKS IN MW

SUBAREA	1960 Energy	1960 Load Factor	1960 Peak	1970 Energy	1970 Load Factor	1970 Peak	1980 Energy	1980 Load Factor	1980 Peak
Grand Rapids	1,908	0.63	345	3,175	0.64	570	5,315	0.65	930
West Central Belt	255	0.50	58	425	0.51	95	710	0.52	155
Lansing	1,235	0.64	220	2,050	0.64	365	3,440	0.66	590
Northeast Fringe	207	0.50	47	345	0.49	80	575	0.52	125
Jackson	545	0.62	100	905	0.63	165	1,520	0.64	270
Total Area	4,150	0.61	770	6,900	0.62	1,275	11,560	0.64	2,070

Table 3 (Cont'd)

SUBAREA	1990 Energy	1990 Load Factor	1990 Peak	2000 Energy	2000 Load Factor	2000 Peak	2010 Energy	2010 Load Factor	2010 Peak	2020 Energy	2020 Load Factor	2020 Peak
Grand Rapids	8,560	0.65	1,500	13,700	0.66	2,360	20,970	0.66	3,630	29,950	0.67	5,090
West Central Belt	1,110	0.55	230	1,790	0.58	350	2,740	0.58	540	3,910	0.60	740
Lansing	5,580	0.65	980	8,940	0.66	1,540	13,680	0.66	2,370	19,530	0.67	3,320
Northeast Fringe	930	0.59	180	1,500	0.61	280	2,280	0.61	430	3,250	0.62	600
Jackson	2,420	0.64	430	3,870	0.64	690	5,930	0.65	1,040	8,460	0.65	1,480
Total Area	18,600	0.64	3,320	29,800	0.65	5,220	45,600	0.65	8,010	65,100	0.66	11,230

Table 4

GRAND RIVER, MICHIGAN

ELECTRIC UTILITY ENERGY PRODUCTION AND PEAK CAPACITY
PRODUCTION IN THE SUBAREAS AND SERVICE AREA

SUBAREA (With Counties)	ENERGY PRODUCTION MILLION KWH							
	1960	1963	1970	1980	1990	2000	2010	2020
GRAND RAPIDS								
Kent and Ottawa	225	1,833	4,917	7,625	10,500	13,380	20,700	28,015
WEST CENTRAL BELT								
Montcalm, Ionia and Barry	54	60	89	195	285	385	610	850
NORTHEAST FRINGE								
Gratiot and Shiawassee	8	8	12	30	45	60	90	125
LANSING								
Eaton, Ingham and Clinton	839	932	1,382	3,035	4,530	6,025	9,600	13,170
JACKSON								
Jackson	0	0	0	0	0	0	0	0
TOTAL SERVICE AREA	1,126	2,833	6,400	10,885	15,360	19,850	31,000	42,160

Table 3 (Cont'd)

SUBAREA	1990 Energy	1990 Load Factor	1990 Peak	2000 Energy	2000 Load Factor	2000 Peak	2010 Energy	2010 Load Factor	2010 Peak	2020 Energy	2020 Load Factor	2020 Peak
Grand Rapids	8,560	0.65	1,500	13,700	0.66	2,360	20,970	0.66	3,630	29,950	0.67	5,090
West Central Belt	1,110	0.55	230	1,790	0.58	350	2,740	0.58	540	3,910	0.60	740
Lansing	5,580	0.65	980	8,940	0.66	1,540	13,680	0.66	2,370	19,530	0.67	3,320
Northeast Fringe	930	0.59	180	1,500	0.61	280	2,280	0.61	430	3,250	0.62	600
Jackson	2,420	0.64	430	3,870	0.64	690	5,930	0.65	1,040	8,460	0.65	1,480
Total Area	18,600	0.64	3,320	29,800	0.65	5,220	45,600	0.65	8,010	65,100	0.66	11,230

Table 4 (Cont'd)

SUBAREA (With Counties)	PEAK CAPACITY PRODUCTION THOUSAND KW							
	1960	1963	1970	1980	1990	2000	2010	2020
GRAND RAPIDS								
Kent and Ottawa	50	318	922	1,415	1,910	2,405	3,690	4,980
WEST CENTRAL BELT								
Montcalm, Ionia and Barry	10	14	16	33	50	68	106	145
NORTHEAST FRINGE								
Gratiot and Shiawassee	2	2	3	7	11	14	22	30
LANSING								
Eaton, Ingham and Clinton	163	195	259	541	823	1,105	1,742	2,380
JACKSON								
Jackson	0	0	0	0	0	0	0	0
TOTAL SERVICE AREA	225	529	1,200	1,996	2,794	3,592	5,560	7,535

The projected power requirements for the Basin Service Area are based upon the growth forecasted for the Area by the Grand River Basin Economic Base Study. The anticipated growth of the Area was analyzed for its likely impact upon the Area's power requirements relative to the power requirements of Power Supply Area 11. As table 3 shows, the Service Area is expected to account for about 15 percent of the Power Supply Area's demand for electric power.

Within the Service Area, the Grand Rapids subarea is expected to account for about 46 percent of the demand, the Lansing subarea 30 percent, the Jackson subarea 13 percent, the West Central subarea 6 percent, and the Northeast subarea 5 percent.

Section B - Energy Production: Historical and Projected

A relatively small share of the Service Area's energy requirements was produced in the Area in 1960 (about 25 percent), as is shown by a comparison between tables 3 and 4. By 1963, however, production in the Area had risen to about 60 percent of Area requirements, due to increased energy production in the Grand Rapids subarea.

Most of the energy produced in the Area comes from the Grand Rapids and the Lansing subareas (95 percent in 1960 and 97.5 percent in 1963). This pattern is expected to persist.

It is projected that, in 1970, over 90 percent of the Area's energy requirements will be internally produced. The increasing self-sufficiency of the Area in the 1960's is due primarily to the installation of two new power plants in the Grand Rapids subarea: a unit of 265,200 kilowatts installed in August 1962; and a unit of 385,000 kilowatts scheduled for service in May 1967.

The long-term projections call for internal production of most, but not all, of the Area's future requirements.

Only commercial production has been projected by the Commission. Non-utility production in the Area is comparatively small (28 million kilowatt-hours in 1960), and increases in its relative importance are not anticipated.

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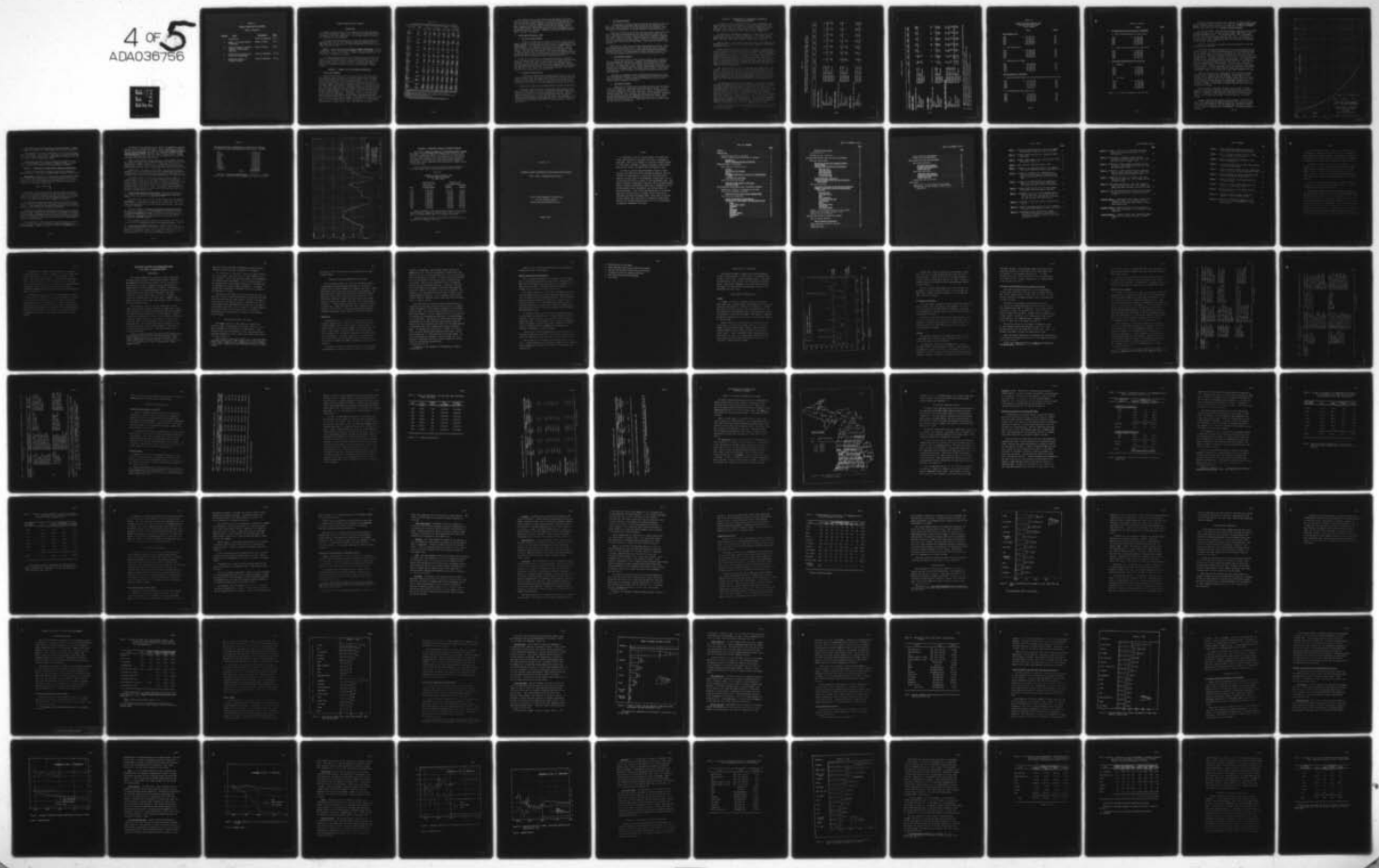

PART III

MINERAL PRODUCTION AND RESERVES

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D	Waterborne Commerce in Mineral Products	Corps of Engineers	III-16

MINERAL PRODUCTION AND RESERVES

Introduction

Mining is a small sector of the economy of the Grand River Basin Service Area (hereafter referred to as the "Area"), accounting for only 0.5 percent of its total employment. The principal minerals produced are petroleum and sand and gravel.

This report contains descriptions of past and present mineral production, known reserves, and waterborne commerce in mineral products. Also contained are projections of mineral production in the Area and subareas from 1960 to 2020.

Part I: Population Growth and General Economic Development contains a description of the relationship of mining to the total economy, data on employment in mining, a discussion of trends in mining productivity, and projections of employment in mining.

The Grand River Basin Service Area has been divided into five subareas: the Grand Rapids subareas (Kent and Ottawa counties); the West Central subarea (Barry, Ionia, and Montcalm counties); the Lansing subarea (Clinton, Eaton, and Ingham counties); the Northeast subarea (Gratiot and Shiawassee counties); and the Jackson subarea (Jackson county).

Section A - Summary of Existing Mineral Production

1. Service Area Summary.

Production of minerals and fuels in the Area in 1962 was valued at $18.6 million, about 4 percent of the mineral production in Michigan. This was more than three times the value of output in 1950, due mainly to a sixfold increase in value of petroleum output. Table A-1 gives details of mineral production in the Area, the subareas, Michigan, and the United States, showing major minerals produced, by quantity and value, for 1950, 1955, 1960, and 1962. Petroleum, along with associated natural gas, is the most important mineral produced, accounting for 56.8 percent of total value produced in the Area in 1962, with sand and gravel (36.6 percent) comprising most of the remainder. The value of gypsum output in Kent County is substantial. The gypsum is produced from two underground mines near Grand Rapids, and processed into gypsum board and other building materials at two plants. Clay production valued at $200,000 is used for brick, and limestone output is used mainly for agricultural lime. Wells in Gratiot County produce brine used in a salt plant and a chemical plant. Outputs of marl, peat, and sandstone are small.

Table A-1

MINERAL PRODUCTION IN THE SUBAREAS, SERVICE AREA, MICHIGAN, AND THE UNITED STATES, 195[illegible]955, 1960, and 1962[a]

Subarea and Commodity	Unit of Measure	1950		1955		1960		1962	
		Quantity	Value, dollars	Quantity	Value, dollars	Quantity	Value, dollars	Quantity	Value, dollars
Grand Rapids									
Gypsum	Short tons	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Marl	Ditto	25,000	16,000	14,000	2,000	1,000	1,000	2,000	1,000
Sand and Gravel	"	2,368,000	(b)	3,769,000	(b)	4,520,000	(b)	3,897,000	(b)
Natural Gas	M cu ft	32,000	4,000	26,000	3,000	22,000	5,000	18,000	4,000
Petroleum	42-gal bbl	282,000	762,000	247,000	720,000	387,000	1,127,000	313,000	892,000
Peat	Short tons	-----	-----	-----	-----	3,000	20,000	4,000	24,000
Total		----------	3,653,000	----------	4,962,000	----------	5,774,000	----------	4,948,000
West Central Belt									
Clay	Short tons	3,000	4,000	-----	-----	-----	-----	-----	-----
Limestone	Ditto	-----	-----	-----	-----	(b)	(b)	-----	-----
Marl	"	21,000	11,000	5,000	3,000	13,000	8,000	14,000	9,000
Sand and Gravel	"	537,000	205,000	642,000	186,000	1,766,000	(b)	1,428,000	(b)
Natural Gas	M cu ft	713,000	94,000	43,000	5,000	385,000	82,000	239,000	51,000
Petroleum	42-gal bbl	298,000	805,000	401,000	1,172,000	631,000	1,835,000	478,000	1,363,000
Peat	Short tons	-----	-----	-----	-----	(b)	(b)	(b)	(b)
Total		----------	1,119,000	----------	1,566,000	----------	3,397,000	----------	2,474,000
Lansing									
Clay	Short tons	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Limestone	Ditto	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Marl	"	2,000	1,000	-----	-----	-----	-----	-----	-----
Sand and Gravel	"	993,000	528,000	1,596,000	1,175,000	1,669,000	1,338,000	2,211,000	1,659,000
Peat	"	-----	-----	-----	-----	(b)	(b)	(b)	(b)
Petroleum	42-gal bbl	(c)	(c)	-----	-----	-----	-----	-----	-----
Total		----------	695,000	----------	1,405,000	----------	1,634,000	----------	1,939,000
Northeast Fringe									
Clay	Short tons	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Sand and Gravel	Ditto	271,000	(b)	514,000	(b)	1,003,000	(b)	479,000	(b)
Natural Gas	M cu ft	466,000	62,000	128,000	15,000	10,000	2,000	11,000	2,000
Petroleum	42-gal bbl	3,000	8,000	74,000	215,000	205,000	596,000	109,000	311,000
Total (d)		----------	274,000	----------	578,000	----------	1,361,000	----------	761,000
Jackson									
Limestone	Short tons	24,000	41,000	37,000	74,000	24,000	57,000	25,000	53,000
Marl	Ditto	4,000	2,000	8,000	5,000	2,000	1,000	3,000	2,000
Sandstone	"	1,000	4,000	9,000	80,000	11,000	94,000	13,000	63,000
Sand and Gravel	"	376,000	259,000	430,000	308,000	462,000	385,000	509,000	413,000
Natural Gas	M cu ft	-----	-----	-----	-----	603,000	129,000	2,232,000	475,000
Petroleum	42-gal bbl	-----	-----	2,000	6,000	1,735,000	5,049,000	2,613,000	7,446,000
Total		----------	306,000	----------	472,000	----------	5,735,000	----------	8,452,000
Total Service Area									
Clay	Short tons	97,000	92,000	101,000	101,000	112,000	168,000	134,000	201,000
Gypsum	Ditto	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Limestone	"	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Marl	"	51,000	30,000	27,000	10,000	16,000	10,000	19,000	12,000
Sandstone	"	1,000	4,000	9,000	80,000	11,000	94,000	13,000	63,000
Sand and Gravel	"	4,545,000	2,999,000	6,950,000	5,962,000	9,420,000	7,427,000	8,523,000	6,794,000
Natural Gas	M cu ft	1,211,000	160,000	197,000	23,000	1,020,000	218,000	2,500,000	532,000
Petroleum	42-gal bbl	584,000	1,576,000	724,000	2,113,000	2,958,000	8,606,000	3,513,000	10,012,000
Peat	Short tons	-----	-----	-----	-----	6,000	38,000	6,000	47,000
Total (d)		----------	6,048,000	----------	8,983,000	----------	17,882,000	----------	18,574,000
Michigan									
Clay	1000 short tons	1,428	1,140	1,918	2,019	1,738	1,904	1,751	1,917
Gypsum	Ditto	1,474	4,091	1,762	5,661	1,463	5,609	1,278	4,791
Stone	"	19,096	15,391	33,636	28,909	31,256	32,274	28,440	29,055
Sand and Gravel	"	24,557	16,699	37,214	29,491	46,910	39,304	47,563	42,029
Natural Gas	M cu ft	11,250	1,485	8,300	955	20,790	4,449	28,987	6,174
Petroleum	1000 42-gal bbl	15,826	42,730	11,266	32,900	15,899	46,266	17,117	48,783
Peat	Short tons	12,750	174	(e)	(e)	214,402	2,755	257,533	2,277
Total, all minerals (000)		----------	229,941	----------	363,787	----------	437,598	----------	446,520
United States									
Clay	1000 short tons	39,381	95,250	48,106	139,540	49,069	162,411	47,797	163,012
Gypsum	Ditto	8,193	22,735	10,684	33,938	9,825	35,690	9,969	36,343
Stone (g)	"	250,844	387,911	467,272	702,142	616,784	952,555	656,954	1,025,697
Sand and Gravel	"	367,304	292,559	591,683	535,510	709,792	720,432	776,701	794,725
Natural Gas	M cu ft	6,282,060	408,521	9,405,351	978,357	12,771,038	1,789,970	13,876,622	2,145,301
Petroleum	1000 42-gal bbl	1,973,574	4,963,380	2,484,428	6,870,380	2,574,933	7,420,181	2,676,185[f]	7,768,822[f]
Peat	Short tons	130,723	1,143	273,669	2,283	470,889	5,138	571,873	5,186
Total, all minerals (000)		----------	11,855,000	----------	15,804,000	----------	18,032,000	----------	18,834,000

(a) Compiled primarily from U. S. Bureau of Mines data, except for petroleum and natural gas production data which were derived essentially from Michigan Geological Survey records.
(b) Figure withheld to avoid disclosing individual company confidential data. However, value data are included in subarea and Service Area totals.
(c) Less than 500.
(d) Incomplete total; data for bromine, calcium compounds, magnesium compounds, and salt not included in order to avoid disclosing individual company confidential data.
(e) Figure withheld to avoid disclosing individual company confidential data.
(f) Preliminary figure.
(g) Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone.

Source: Grand River Basin data compiled by the U.S. Bureau of Mines, Area III Mineral Resource Office, Minneapolis, Minnesota, February, 1964.
Michigan and United States figures compiled by Battelle from Minerals Yearbook (U.S. Bureau of Mines), 1951, 1956, and 1962.

Petroleum production, which had been fairly steady in the early 1950's at 550,000 - 750,000 barrels per year (mainly from the West Central Belt and Grand Rapids subareas), increased to 3,000,000 barrels per year by 1960 (most of the increase coming from the Jackson subarea). Total cumulative petroleum production from the Area through 1962 was 34.7 million barrels, of which 95 percent had come from Montcalm, Kent, and Ottawa counties. The Area's cumulative production through 1962 was about 7 percent of Michigan's.

2. Production by Counties: 1963

a. The Grand Rapids Subarea

Production in Kent County included (in order of value) sand and gravel, gypsum, petroleum, peat, and natural gas. Two underground mines yielded gypsum. The crude material was processed at company-owned plants where wallboard, lath, sheathing, and plaster are produced. Perlite mined in Nevada was expanded in these plants, and used for building plaster. Peat was dug from bogs near Grand Rapids and Wyoming. Over 2.7 million tons of sand and gravel were produced from large fixed plants in the Grand Rapids area and from portable plants throughout Kent County. Natural gas and petroleum were produced from the Walker field.

Production in Ottawa County included sand and gravel, petroleum, stone, and natural gas. Nearly 2.5 million tons of sand and gravel were produced, up from 1.8 million in 1962. Industrial sand as well as sand and gravel for building, paving, and fill was reported. Marl was dug near Hudsonville and Jenison. More than 192,000 barrels of petroleum and 138 million cubic feet of natural gas were recovered. The largest production was reported from the Walker field.

b. The West Central Subarea

Production in Barry County included sand and gravel, petroleum, stone, and peat. Marl was dipped from deposits near Caledonia and Nashville and was sold for agricultural use. Pits throughout Barry County yielded sand and gravel for road use, building, fill, and ice control. Small quantities of peat and petroleum were also produced in the County.

Production in Ionia County included sand and gravel and petroleum.

Production in Montcalm County included petroleum, sand and gravel, peat, and natural gas. Production of petroleum (343,000 barrels) and natural gas (137 million cubic feet) continued to decline. Most of the petroleum production, as in 1962, came from the Elmore and Reynolds fields. During the year, the Day and Pine fields were abandoned. A bog near Lakeview yielded peat (reed-sedge and moss). About 265,000 tons of sand and gravel were produced for building and road use. Crude oil was refined.

c. The Lansing Subarea

Production in Clinton County included sand and gravel, clays, and peat. Clay was mined near Grand Ledge and used in the manufacture of sewer pipe. About 300,000 tons of sand and gravel were produced, mostly for paving and building use. Peat was produced for horticultural use.

Production in Eaton County included sand and gravel, stone, clays, and peat. Sewer pipe was manufactured from clay mined near Grand Ledge. A quarry operating near Bellevue produced agricultural limestone, roadstone and a small quantity of rubble. Sand and gravel was produced throughout the County, mostly with portable plants. Most of the sand and gravel was used for road construction and maintenance. Humus peat was produced near Charlotte.

Production in Ingham County included sand and gravel and peat. Peat was produced from a bog near Delhi. About one million tons of sand and gravel were produced, most of it for road construction and maintenance, building, and fill. The Lansing Board of Water and Light recovered lime from calcium carbonate precipitated in its water purification process.

d. The Northeast Subarea

Production in Gratiot County included salines, salt, petroleum, sand and gravel, and natural gas. Bromine, calcium-magnesium chloride, magnesium compounds, and salt were produced from natural well brines at St. Louis. At Alma, crude oil was refined, and byproduct sulphur was recovered by a hydrofining process. About 71,000 barrels of petroleum were produced from the Summer field. North Star field produced a small amount of natural gas. Sand and gravel for building and paving was produced by four operators.

Production in Shiawassee County included sand and gravel and clays. Clay was mined near Corunna for use in manufacturing vitrified sewer pipe. About 345,000 tons of sand and gravel were produced in both fixed and portable plants throughout the County.

e. The Jackson Subarea

Production in Jackson County included petroleum, sand and gravel, stone, and natural gas. Petroleum output continued to decline, to about 2.3 million barrels in 1963, from 2.6 million in 1962. Natural gas was virtually unchanged at 2.2 billion cubic feet. More than 500,000 tons of sand and gravel for fill, building, and paving use was produced. Roadstone and agricultural limestone was quarried and crushed near Parma. Three quarries near Napoleon yieled sandstone which was milled for building use and crushed for foundry use. Broken stone was used for riprap. Marl was dug from a pit near Horton.

Section B - Projected Mineral Production - Details on Methodology; Reserves

In accordance with an agreement with the Corps of Engineers, the Bureau of Mines developed projections of mineral production for 1970, 1980, 1990, 2000, 2010, and 2020 in the Grand River Basin Service Area, Michigan. The projections, broken down by mineral commodities and economic subregions within the area, are presented in Table B-1.

As over half of the minerals produced in the Area are used in the construction industry, the Corps of Engineers, at the request of the Bureau of Mines, supplied projections of construction in the Area for 1970, 1980, 1990, 2000, 2010, and 2020, summarized in Table B-2.

Sand and gravel, accounting for over 80 percent of the construction minerals produced in the Area, was the principal commodity projected by the Bureau of Mines.

Using the data provided by the Corps of Engineers on construction activity, projections were made of the value of sand and gravel produced in the subarea, at ten year intervals for 1970-2000. For each subarea the projections were made for sand and gravel for new highway construction, highway maintenance and repair, and other construction. The percent change in new highway construction for each period was applied to 70 percent of the sand and gravel used for road material. The other 30 percent was projected at the rate of change for road maintenance and repair. Sand and gravel used for other purposes was projected by the rate of change in "other" construction.

The data provided by the Corps of Engineers were expressed in 1960 dollars. The base for projection used by the Bureau of Mines was 1960 data for sand and gravel production, value, and average price per ton. As the raw data were not considered representative for projection purposes a time series 1953-1963 was used to develop data for each subarea. Using the method of least squares, equations were derived from the time series and 1960 figures obtained for production, value, and price per ton.

The agreement between the Corps of Engineers and the Bureau of Mines specified that mineral output be projected in physical units. In order to convert value of sand and gravel to short tons, time series were developed for the period 1953-1962 on sand and gravel productivity in the state of Michigan. The time series reflected tons per man-hour and value (in 1960 dollars) per man-hour. Using the method of least squares, equations were derived and projections made of these data for the periods 1970, 1980, 1990, 2000. Using the price per ton (in Michigan) in 1960 as the base or 100 percent, the price in each of the projection years was expressed as a percentage of the 1960 price. The 1960 price of sand and gravel in each subarea, as determined by the least squares equation, was adjusted for each projection year by the appropriate percentage.

Finally, production in short tons for each projection year was obtained by dividing the projected value of production by the adjusted price per ton of sand and gravel.

Table B-1

MINERAL PRODUCTION IN THE GRAND RIVER BASIN SERVICE AREA, MICHIGAN IN 1960 WITH PROJECTIONS FOR 1970, 1980, 1990, 2000, 2010 AND 2020 [1/]

Subarea and Commodity	Unit of Measure	1960[4/]	1970	1980	1990	2000	2010	2020
GRAND RIVER SUBBASIN								
Kent and Ottawa Counties								
Gypsum	Thousand short tons	2/	2/	2/	2/	2/	2/	2/
Marl	Thousand short tons	1	1	1	1	1	1	1
Sand and Gravel	Thousand short tons	4,325	6,100	8,750	11,700	16,000	22,000	30,000
Peat	Thousand short tons	3	4	5	6	8	10	12
Natural Gas	Thousand MCF	22	20	18	16	14	12	10
Petroleum	Thousand 42-gallon barrels	387	300	250	200	160	130	100
WEST CENTRAL SUBAREA								
Barry, Ionia and Montcalm Cous.								
Marl	Thousand short tons	13	13	13	12	12	10	10
Sand and Gravel	Thousand short tons	1,400	2,000	2,800	3,750	5,200	7,000	9,500
Peat	Thousand short tons	2/	1	1	2	2	3	4
Natural Gas	Thousand MCF	385	100	50	25	-	-	-
Petroleum	Thousand 42-gallon barrels	631	200	100	50	-	-	-
LANSING SUBAREA								
Clinton, Eaton, and Ingham Cous.								
Clay	Thousand short tons	2/	60	80	100	140	190	250
Limestone	Thousand short tons	2/	165	250	325	420	575	780
Sand and Gravel	Thousand short tons	1,800	2,500	3,400	4,500	6,250	8,500	11,500
Peat	Thousand short tons	2/	3	4	5	6	8	10

Table B-1 (Cont'd)

Subarea and Commodity	Unit of Measure	1960 4/	1970	1980	1990	2000	2010	2020
NORTHEAST SUBAREA								
Gratiot and Shiawassee Cous.								
Clay	Thousand short tons	2/	75	100	125	170	230	300
Sand and Gravel	Thousand short tons	600	850	1,200	1,600	2,200	3,000	4,000
Natural Gas	Thousand MCF	10	10	-	-	-	-	-
Petroleum	Thousand 42-gallon barrels	205	50	-	-	-	-	-
JACKSON SUBAREA								
Jackson County								
Limestone (includes sandstone)	Thousand short tons	35	50	75	100	125	170	230
Marl	Thousand short tons	2	2	2	2	2	2	2
Sand and Gravel	Thousand short tons	575	800	1,100	1,450	2,000	2,750	3,750
Natural Gas	Thousand MCF	603	1,000	100	100	100	100	100
Petroleum	Thousand 42-gallon barrels	1,735	900	175	150	125	100	100
TOTAL GRAND RIVER BASIN SERVICE AREA								
Clay	Thousand short tons	112	135	180	225	310	420	550
Gypsum	Thousand short tons	2/	2/	2/	2/	2/	2/	2/
Limestone 3/	Thousand short tons	2/	215	325	425	545	745	1,010
Marl	Thousand short tons	16	16	10	15	15	13	13
Peat	Thousand short tons	6	8	10	13	16	21	26
Sand and Gravel	Thousand short tons	8,700	12,250	17,250	23,000	31,750	43,250	58,750
Natural Gas	Thousand MCF	1,020	1,130	168	141	114	112	110
Petroleum	Thousand 42-gallon barrels	2,958	1,450	525	400	285	230	200

1/ Compiled primarily from U.S. Bureau of Mines data, except for natural gas and petroleum production data which were derived from Michigan Geological Survey records.

2/ Figure withheld to avoid disclosing individual company confidential data.

3/ Includes sandstone produced in the Jackson subarea.

4/ See text for explanation of divergence between Table A-1 and B-1.

Table B-2

GRAND RIVER BASIN SERVICE AREA
CONSTRUCTION PROJECTIONS
(1960 DOLLARS)

	Value	Index
1. **Total Construction**		
1960	$ 381,000,000	100
1970	477,000,000	125
1980	615,000,000	161
1990	778,000,000	204
2000	1,060,000,000	278
a. New Construction		
1960	$ 283,000,000	100
1970	345,000,000	122
1980	434,000,000	153
1990	539,000,000	190
2000	734,000,000	259
b. Maintenance and Repair		
1960	$ 98,000,000	100
1970	132,000,000	135
1980	181,000,000	185
1990	239,000,000	244
2000	326,000,000	333
2. **New Construction - Breakdown**		
a. Residential New Construction Including Additions and Alterations		
1960	$ 113,000,000	100
1970	145,000,000	128
1980	192,000,000	170
1990	232,000,000	205
2000	338,000,000	299
b. Non-Residential New Construction		
1960	$ 170,000,000	100
1970	200,000,000	118
1980	242,000,000	142
1990	307,000,000	181
2000	396,000,000	233

Table B-2 (Cont'd)

	Value	Index
3. Non-Residential New Construction - Breakdown		
a. Public New Non-Residential Construction		
1960	$ 76,000,000	100
1970	92,000,000	121
1980	114,000,000	150
1990	150,000,000	197
2000	200,000,000	263
b. Private New Non-Residential Construction		
1960	$ 94,000,000	100
1970	108,000,000	115
1980	128,000,000	136
1990	157,000,000	167
2000	196,000,000	209
4. Public New Non-Residential Construction		
a. Highways		
1960	$ 28,000,000	100
1970	36,800,000	131
1980	49,500,000	177
1990	63,600,000	227
2000	82,000,000	293
b. All Other		
1960	$ 49,000,000	100
1970	55,200,000	113
1980	64,500,000	132
1990	86,400,000	176
2000	114,000,000	233

Source: U. S. Corps of Engineers, see Section C.

All Bureau of Mines dollar data were converted to 1960 dollars by using the construction deflator in Table A 1-7, page 525, Resources in America's Future. Construction deflators for the period 1961 - 1963 were obtained from the July, 1964 issue of the Survey of Current Business.

For the period 2000 - 2020 the Bureau of Mines employed the projections on gross national product developed by the Economic Task Group of the ad hoc Water Resources Council. For the period 2000 - 2010 a percentage increase of 37 percent was used, and for 2010 - 2020, an increase of 36 percent. These rates of change paralleled the rates of growth used for the period 1960 - 2000, although the latter were determined independently of the "ad hoc" projections.

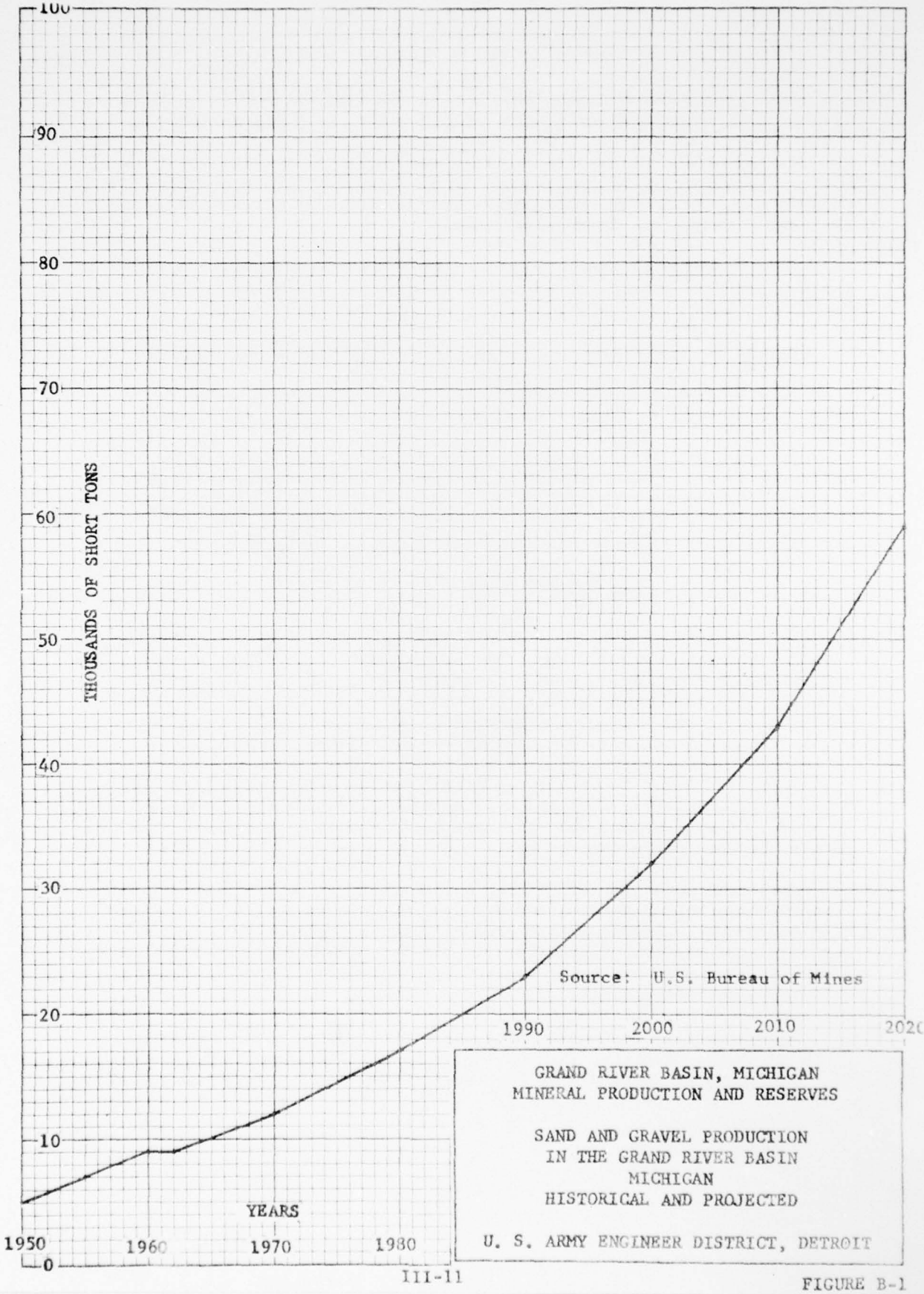
Figure B-1 depicts the historical and projected growth of sand and gravel output in the Area.

Natural gas and petroleum production in the Jackson subarea has just passed its peak. According to mineral specialists in the Michigan Department of Conservation, production in the subarea will continue to decline, and by 1980 the fields of the Albion-Pulaski-Scipio trend should be on a stripper basis. Indicated petroleum reserves in the subarea are about 16 million barrels, according to the Oil and Gas Journal. In the Grand Rapids and West Central subareas the Traverse and Dundee-Reed City formations have been yielding petroleum and natural gas since 1927. The production peak was reached between 1935 and 1945. Since then there has been a gradual decline in output, but substantial yields are still being registered each year. The State Geological Survey indicated that the geological formations in the Area should provide normal opportunities for oil discoveries. There is no evidence as to when these strikes will be made.

Limestone was projected by applying the rate of change in highway construction to limestone used as roadstone. Agricultural limestone was projected by applying the rate of change in lime used per acre of cropland in the Area for each of the projection years from data supplied by the Economic Research Service, U. S. Department of Agriculture, East Lansing, Michigan. The Department of Agriculture indicated that no significant change in the amount of cropland limed was expected during the projection period.

Marl which has a high bulk/low value ratio is mined in limited quantities in the Area. Because of transportation costs its market is generally limited to a relatively small area around the source of the material. Production is not expected to increase in the foreseeable future. Over a long term, because of limited reserves, output may decline.

Gypsum is mined by two companies in Kent County. Since 1950, output of crude gypsum has declined by nearly half, but in the past three years production appears to have been stabilized. Reserves are ample and should permit production at the current rate over the projection period. Since the current rate is confidential, the projection must be concealed.



GRAND RIVER BASIN, MICHIGAN
MINERAL PRODUCTION AND RESERVES

SAND AND GRAVEL PRODUCTION
IN THE GRAND RIVER BASIN
MICHIGAN
HISTORICAL AND PROJECTED

U. S. ARMY ENGINEER DISTRICT, DETROIT

FIGURE B-1

Peat production and peat reserves in the Area are small. Output is expected to increase at a rather modest rate, as shown in table B-1.

Clay produced in the Area is used mostly for drain pipe and other heavy clay products. Clay output is projected to increase at about the same rate as "other construction" -- approximately 25 percent to 30 percent every 10 years. Reserves are ample.

Summarizing, the Area's output of construction materials, particularly sand and gravel, is projected to increase steadily, but its output of fuels will probably decline as reserves are depleted.

Section C - Projections of Construction - Details on Methodology

Construction projections furnished by the Corps of Engineers, Detroit District, to the Bureau of Mines appear on pages III-8 and III-9.

1. Methodology. Projections of construction for the Grand River Basin Service Area are approximately 0.5 percent of the Resources for the Future "Low" construction projections, multiplied by the ratio of the Resources for the Future "Middle" and "Low" population projections. Symbolically, this can be expressed as:

$$C_{GRB} = 0.005\ C_L \frac{P_M}{P_L}.$$

Projection of local historical data was not relied upon because such data are not readily available in time series form. Independent projection of nationwide historical data was considered, but the number, variety, and complexity of the relevant assumptions necessitated recourse to an already-existent body of thought on the subject.

The Grand River Basin Service Area contained 0.61 percent of the Nation's population in 1900 and 0.61 percent of the Nation's population in 1960. It was assumed that the area would continue to contain approximately the same percentage of the Nation's population.

Construction employment in the Area has varied in the last quarter century between 0.45 percent and 0.55 percent of the Nation's construction employment. Assuming that productivity in the Area's construction industry approximates productivity in the Nation's construction industry, the value of the Area's total construction activity in 1960 exceeded a third of a billion dollars.

The categories of construction used in the projections correspond to those in the Resources for the Future publication Resources in America's Future. Appendix to Chapter 4, Table A 4-3, pages 615 and 616.

The growth of new construction per capita, if expressed in constant prices, has not in the past been rapid. This is evidenced by figure C-1, derived from the Department of Commerce, publications, Historical Statistics of the United States, Series N 29-54, pages 381 and 382, and Construction Reports C 30-60, July 1964, Table V, pages 8 and 9. (Figure C-1 and the text discussion below use 1947-1949 dollars, to accord with the usage of the principal data source).

Peaks of new construction were reached in 1926 and 1955, which had per capita new construction (in 1947-1949 dollars) of $202.32 and $215.16, respectively. However, these are not, to judge from the historical record, typical years. The average new construction per capita during the years 1915-1925 was $132.23; during the years 1927-1954 it was $131.41.

Historically, new construction has been a boom and bust industry. Although a line drawn through the peaks would underestimate the potential of the industry, it would be equally over-optimistic to assume that the 1946-1955 rise in new construction was representative of a long-term trend.

The Resources for the Future-Middle-Range Estimate assumes that new construction will reach a level of $580.89 (1947-1949 dollars) per capita in 2000. Since the 30-year span from 1926 to 1955 produced a peak-to-peak growth of only $12.84 per capita, it seems over-optimistic to assume a growth of $374.24 per capita in the 38-year span from 1962 (a very good construction year) to 2000. Consequently, the Resources for the Future Low per capita new construction projections were used in preference to the Middle projections.

2. Notes on Data Sources and Price Ratios. New construction for the years 1915-1957 was derived from Historical Statistics of the United States (1957), Series N 29-54, pages 381 and 382.

New construction for the years 1958-1962 was derived from Construction Reports, C 30-60, Table V, pages 8 and 9. These data are in 1957-1959 dollars, and have been converted to 1947-1949 dollars. The ratio between the two series for 1957, the latest year available, was assumed to hold for 1958-1962.

The ratio between the Historical Statistics of the United States new construction estimate for 1950 (expressed in 1947-1949 dollars) and the Resources in America's Future new construction estimate for 1950 (expressed in 1960 dollars) yielded a price ratio that was used to convert Resources in America's Future projections (expressed in 1960 dollars) into 1947-1949 dollars.

The estimates of national population for the years 1915-1962 were taken from the 1963 Statistical Abstract of the United States, Table No. 2.

3. Projections of Highway Construction. Highway construction projections are important to this analysis since two-thirds of the sand and gravel production in Michigan is used for highway construction. Projections of new highway construction, presented in Table C-1, are based upon estimates made by the Michigan State Highway Department.

TABLE C-1

PROJECTED NEW HIGHWAY CONSTRUCTION, IN CONSTANT 1960 DOLLARS, FOR COUNTIES OF THE GRAND RIVER BASIN SERVICE AREA, 1960-1980

Kent	$240,000,000
Ottawa	65,000,000
Montcalm	40,000,000
Ionia	45,000,000
Barry	30,000,000
Eaton	60,000,000
Clinton	50,000,000
Ingham	140,000,000
Gratiot	45,000,000
Shiawassee	45,000,000
Jackson	65,000,000
Total	$825,000,000

Reference: Michigan's Highway Needs. A Technical Engineering Report, 1962; 122 pp., Source: Michigan State Highway Department.

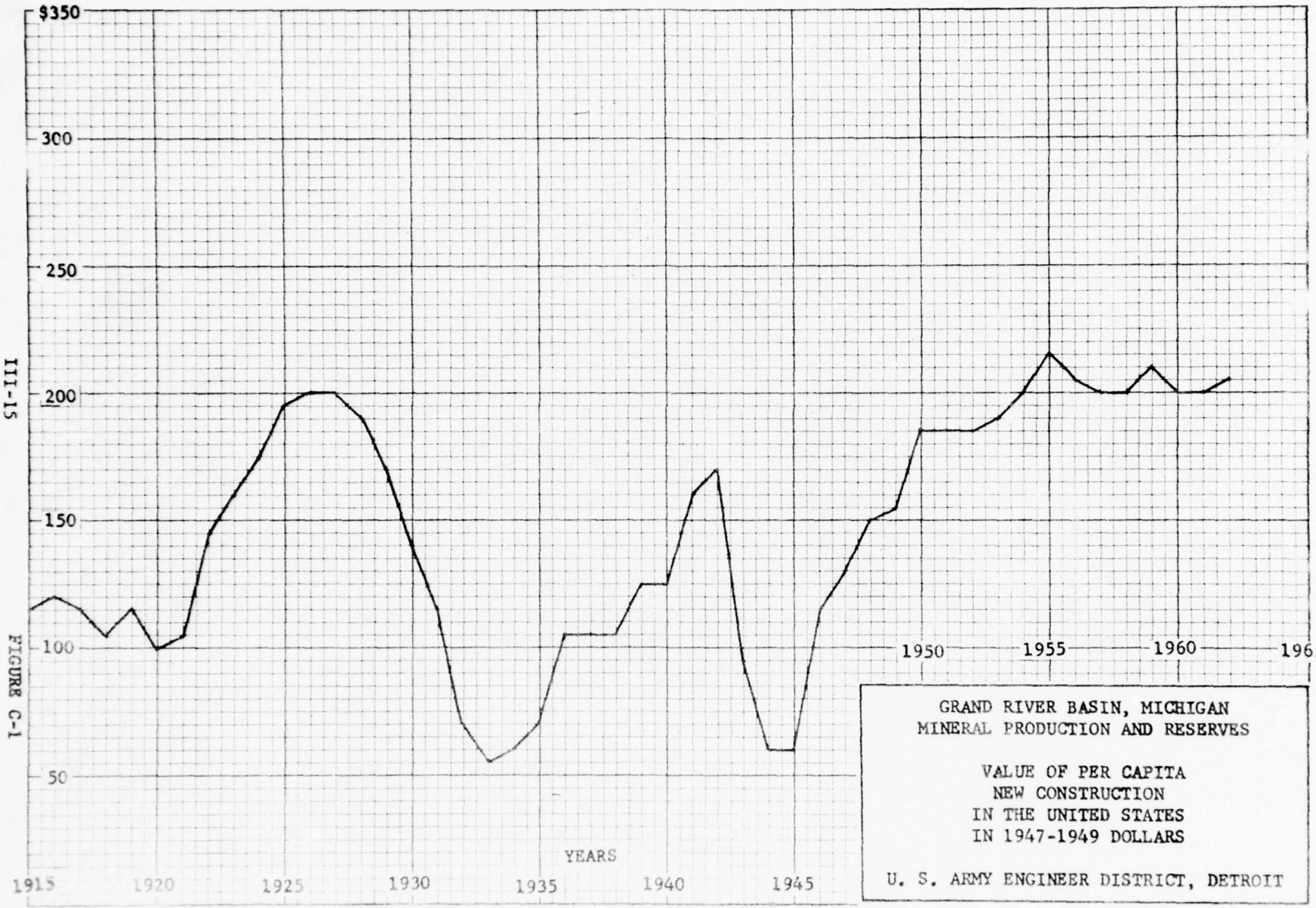

$350
300
250
200
150
100
50
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
196
YEARS
GRAND RIVER BASIN, MICHIGAN
MINERAL PRODUCTION AND RESERVES
VALUE OF PER CAPITA
NEW CONSTRUCTION
IN THE UNITED STATES
IN 1947-1949 DOLLARS
U. S. ARMY ENGINEER DISTRICT, DETROIT

FIGURE C-1

Section D - Waterborne Commerce in Mineral Products

According to Waterborne Commerce of the United States, Calendar Year 1963, the Port of Grand Haven handled heavy traffic in sand and gravel. Grand Haven Harbor, at the mouth of the Grand River, received 1,481,230 short tons of sand and gravel in 1963 from the Bass River area, located on the Grand River 15 miles upstream of Grand Haven. In that same year, Grand Haven Harbor shipped out 659,991 short tons in lakewise trade, and exports to Canada totaled 135,592 short tons.

Table D-1 provides statistics on trade in sand and gravel in Grand Haven Harbor and in the Grand River from 1953 to 1963.

Table D-1

SHIPMENTS OF SAND AND GRAVEL INTO AND FROM GRAND HAVEN HARBOR
(IN SHORT TONS)

Year	Intraport Shipments; Upstream Grand River to Grand Haven	Shipments from Grand Haven	
		Lakewise Traffic	Canadian Exports
1953	1,954,625	1,057,282	21,638
1954	2,216,397	1,354,715	90,386
1955	1,529,296	750,975	112,661
1956	1,594,448	697,478	178,943
1957	1,751,124	961,829	131,345
1958	1,500,025	592,538	189,669
1959	1,713,841	908,722	230,705
1960	1,638,564	801,947	166,918
1961	1,322,112	455,041	147,891
1962	1,347,011	546,409	203,985
1963	1,481,230	659,991	135,592

About 25 percent of the sand and gravel extracted in the Grand Rapids subarea is shipped from Grand Haven, either to other U. S. ports on the Great Lakes (20%) or to Canadian ports (5%).

Among the mineral products shipped into Grand Haven are coal, gasoline, oil, limestone, and slag.

PART IV

AGRICULTURAL ACTIVITY IN THE GRAND RIVER BASIN

1970 - 2020: A PROJECTIVE STUDY

United States Department of Agriculture
Economic Research Service
Natural Resource Economics Division

January 1966

Preface

A comprehensive plan for the development of the water and related land resources of the Grand River Basin in Michigan is being made. The plan is intended to include the combined interest of flood control, drainage, irrigation, navigation, water supply, water quality control, recreation and other beneficial uses.

In order to provide broad and adequate coverage of these interests, the Grand River Basin Coordinating Committee, which is composed of representatives of the several State and Federal agencies including those of the Department of Agriculture, will be coordinating the studies in support of the comprehensive plan. The Corps of Engineers, Department of the Army, one of the participating agencies studying the Grand River Basin, has a leadership role for the development of the comprehensive plan and the conduct of supporting studies. One of the supporting studies is an economic base study with projections of economic activity that can be translated into water development needs. This report is the agricultural economic base study which is supported by funds transferred to the Economic Research Service, U.S.D.A. from the Corps of Engineers, Department of the Army.

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SUMMARY

The long-term agricultural outlook of the Grand River Basin in Michigan is summarized in this report for use by agencies in water resource development planning. This report, as a part of the economic base study, is one of the first phases in preparing a comprehensive plan for developing the area's water resources.

The primary objective of the study is to estimate patterns of agricultural production and land use that farmers are likely to adopt in satisfying future agricultural demands for food and fibre. Other objectives include the estimate of rural-farm population and employment for the eleven-county Grand River study area. The study is oriented to projection dates of 1980, 2000 and 2020.

Projections into the distant future are extremely tenuous, therefore projections after 1980 especially should be considered as indicators of directional change only.

Future requirements for food and fibre were developed for the United States based on projected per capita consumption rates and the population assumptions in the comprehensive study. Shares of the major commodity requirements were distributed to the ten major water resource areas and further distributed to a 42-county sub-region containing the study area. Economic budgeting procedures were used to simulate farmers' decisions to use their soils in meeting production requirements. Land use and production patterns projected for the Basin depend on the relative productivity of soils in and out of the Basin and the respective costs of production.

Total available cropland for agricultural use is expected to decrease because of related non-farm uses. However, under the assumed conditions of the study, sufficient cropland exists to provide the production requirement for 1980 and later projection years. After 1980, however, less productive soils will be used, some of which might be best suited to pasture and forest production. Consequently, agricultural resource development, through irrigation, drainage and flood protection, may be a more efficient means of production.

Feed grain and roughage production requirements were related to the expected regional livestock production patterns. Fertilizer use is projected to double and application rates per acre will increase accordingly. Farm numbers will continue to decline as smaller farms are consolidated into larger more specialized units. Labor-saving technologies will contribute to the continued decline in farm labor requirements. Rural farm population is expected to decrease as farm numbers decrease and as farm families become smaller.

AGRICULTURAL ACTIVITY IN THE GRAND RIVER BASIN 1970 - 2020: A PROJECTIVE STUDY*

INTRODUCTION

This report summarizes the results of a study on the long-term agricultural outlook of the Grand River Basin. The kinds and quantities of agricultural products likely to be produced in the Basin are projected. In addition, rural farm population numbers and rural farm employment are estimated. The purpose of this report is to provide supplementary information to be utilized in the comprehensive plan for the development of the water resources of the Grand River Basin. The plan is intended to include the combined interest of flood control, drainage, navigation, irrigation, water supply, water quality control, recreation and other beneficial uses.

The comprehensive plan for the development and use of an area's water resources requires information of many types. Among these are studies of population concentrations and the requirements for domestic water and water-quality control measures. Another concerns the concentration of industry with high water requirements or contributions to pollution. Water may not be available in sufficient quantities and qualities to provide for some of the beneficial uses. Resource development may be required to provide for water supply and quality in these instances. Even then, all of the uses may not be satisfied. Individual studies of each

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*This report was prepared by John Hostetler and Melvin Cotner, Agricultural Economists, Natural Resource Economics Division, Economic Research Service, U. S. Dept. of Agriculture. Helpful review comments and suggestions were made by members of the Michigan Agricultural Experiment Station, Soil Conservation Service, U. S. Public Health Service, Corps of Engineers and Economic Research Service.

beneficial use are necessary to determine the gains or losses incurred if a particular use is satisfied or restrained.

The future need for and value of additional water in agriculture is of primary concern as one of the many alternative uses to be appraised. Rural farm population numbers can be translated into domestic water requirements. Livestock numbers implicit in the cropping and livestock production patterns in the Basin can be translated into livestock water requirements. Subsequent studies can be undertaken to determine the need for irrigation and drainage in the Basin.

The plan for this report is to first describe the objective and scope of this study and then describe the major physical characteristics and land-use trends that are relevant to the agricultural economy of the Grand River Basin. Following this section, the general procedure and methodological approach to the agricultural economic base study will be presented. Subsequent chapters will present results from the major steps in the analysis. Assumptions and limitations will be discussed in each chapter where relevant.

Objective and Scope of the Study

The primary objective of this study is to identify the pattern of land use that farmers in the Basin likely will use to satisfy demands for food and fibre in future decades. Other objectives include the development of rural farm population and employment estimates for the 11-county study area.[1/] Projections

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[1/] The following counties are included in the Grand River Basin study area in this report: Kent, Ottawa, Barry, Ionia, Montcalm, Clinton, Eaton, Ingham, Gratiot, Shiawassee and Jackson. Hereafter, in this report, references to the "study area" will relate to these counties.

are made for 1980, 2000 and 2020 with interpolations for intervening decades.

General Procedure and Methodological Approach

The future agricultural use of the land and water resource in the Grand River Basin depends importantly on the kinds of food and fibre products consumers will demand in the future. Grand River Basin farmers serve both national and foreign markets. The amount and kind of agricultural production forthcoming from the Basin also depends heavily upon the future productivity of the agricultural land base. Grand River Basin farmers must compete with other basins and regions in the production of agricultural commodities. Several nonagricultural uses of land, such as urban, recreation and highway development also have a bearing on land available for agriculture. The general methodological approach represents an attempt to take these major forces into account.

Methodology

The principal tool for projecting future land use is the economic budgeting model. Simply, the economic budgeting model simulates farmers' decisions with respect to land use when confronted with an expected consumer demand for food and fibre. The logic of the economic budgeting model is that resource owners tend to organize their resources to maximize profits and minimize costs of production. The model is modified to reflect decisions or resource owners that are not wholly profit-oriented or are made because of certain unavoidable constraints in the use of their resources.

To utilize the model, the allocated share of national demand or requirements for food and fibre must be known for the region

or basin to be analyzed. This includes domestic and foreign demands as well as livestock requirements for feed grains. The acreage of the various kinds and qualities of soils in the agricultural land base must be available. For each soil group, projected yield for the potential crops and the costs of production must be developed. The projected yields must reflect the expected adoption of existing and new technology. Production costs must reflect the technological changes in production techniques and account for possible substitution of one input for another. The operation of the budgeting model involves the selection of those cropping patterns, among all of the alternative cropping possibilities, that will maximize economic gain within the constraints likely to confront farmers.

In the application of these procedures several analytical techniques are used; many of which require the use of a computer. "Linear programming" is the computer counterpart of the economic budgeting model. The economic budgeting model can be set up two ways on the computer. One is to maximize profits from a given set of resources with the assumption that there is unlimited demand for food and fibre. The second is to start with a given demand or requirement for food and fibre and budget the most profitable and efficient way of producing this product.[2/] The second approach is used and is called the "minimum cost" economic budgeting model. By starting with a given level of demand for food and fibre, we can be assured that production in the nation, region and sub-basins will be consistent with the national demand. In using the minimum-cost approach in projecting land use, it is necessary to determine the likely effective demand for food and fibre on a national and regional basis.

[2/] Implicit in this approach is the assumption of market clearing prices.

Details of this methodological approach will be presented in subsequent sections of this report.

General Assumptions and Limitations

One of the basic assumptions is that there will be no major wars or recessions during the projected period. In addition, a high level of economic activity and nearly full employment of the labor force are assumed. Periodic cyclical adjustments in economic activity within the economy could occur.

The Economic Task Group of the Ad Hoc Water Resources Council Staff has made population, labor force and employment projections for use in water resource development planning. These assumptions and projections were adopted for this study. Population is projected to increase by 2.7 times between 1960 and 2020. Labor force and employment are projected to increase at a greater rate than population because of higher participation rates and changing age group distributions.

In the agricultural sector government programs are assumed to be existent over the study period. However, market forces are expected to play a major role in allocation of resources among regions and farms. Average weather conditions and farm management ability are assumed over the study period. However, the average level of a farmer's ability to manage his farm business is expected to increase as it has in the past.

Should any of the above assumptions not exist in the future, these projections can be expected to be in error. These may not be the only assumptions that could result in different projections.

The sections to follow pertain to the major elements of the study. Further elaboration of procedures, assumptions and limitations, and a presentation of results will be made in each chapter. The chapters are--

A. Characteristics of the Basin

B. Region and Basin Agricultural Production Potential

C. National and Regional Food and Fibre Requirements

D. Cropping and Livestock Production Patterns

E. Rural Farm Population and Employment

F. Conclusions

CHARACTERISTICS OF THE BASIN

The Grand River Basin, located in west central Michigan, consists of approximately 3.5 million acres of relatively level to gently rolling land. The main drainage channel of the Basin, the Grand River, rises in south central Michigan, in Hillsdale County. From there it meanders first to the north, then west, and empties into Lake Michigan at Grand Haven, as part of the Great Lakes drainage system.

Major Physical Characteristics

Climate

Climate in the Basin is similar to much of the central Great Lakes area. Average snowfall in the Basin is 55.9 inches and precipitation averages 29.3 inches per year (Figure 1). Temperature and precipitation patterns vary throughout the Basin. In the western part, Lake Michigan modifies the temperature, reducing the extremes of both winter and summer. The moderate climate has allowed the development of a "fruit belt" in the counties adjacent to Lake Michigan.

Greater variation in precipitation is experienced by the western part of the Basin which ranges from 26 to 36 inches in Ottawa, Kent, Montcalm and Barry counties. The eastern part averages between 30 and 35 inches per year in the counties of Ionia, Gratiot, Clinton, Shiawassee, Eaton, Ingham and Jackson. Precipitation is fairly evenly distributed throughout the year with slightly more rain during the growing season; thus, the likelihood of severe drought is small.

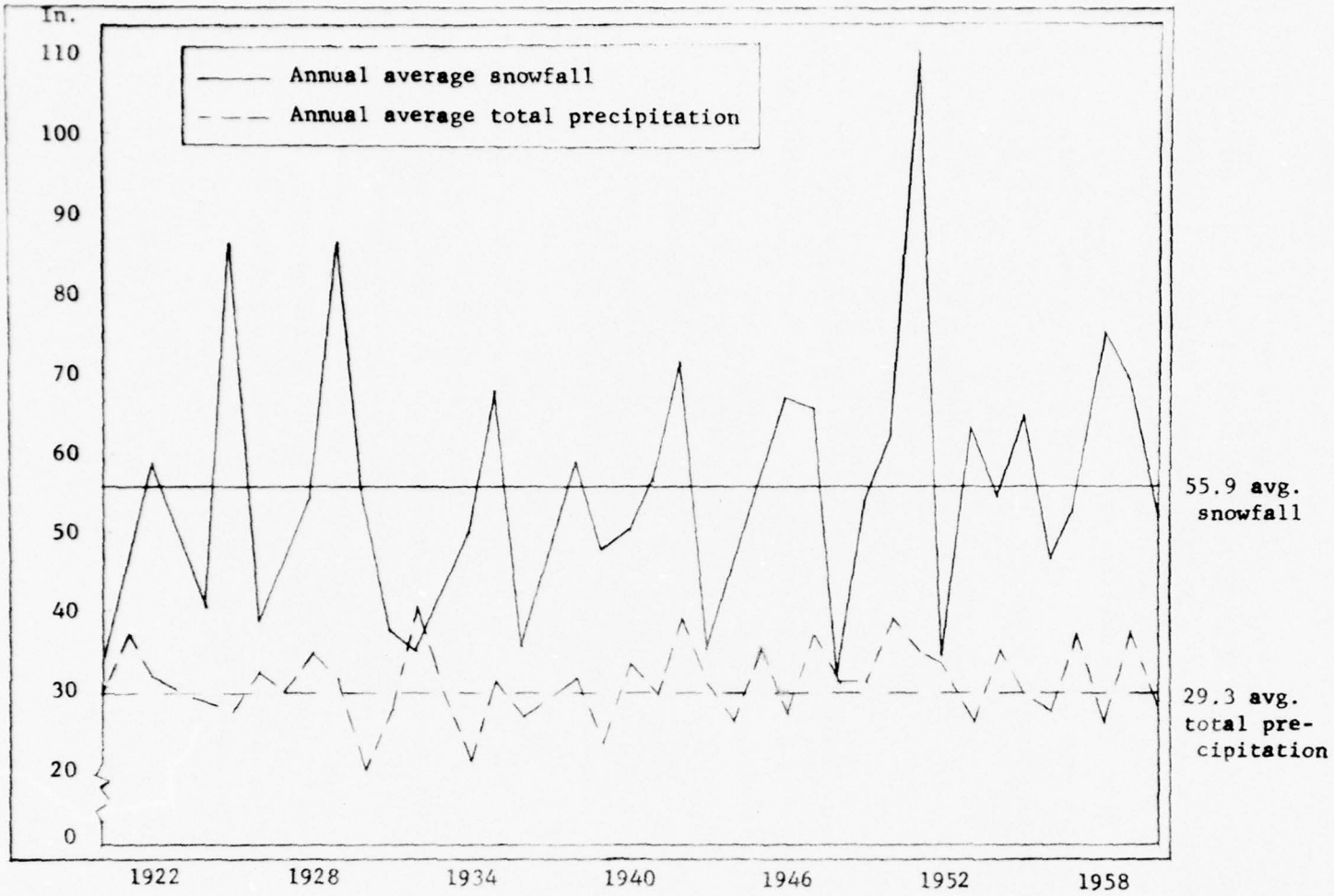

Figure 1. Annual average precipitation and snowfall, Grand River Basin Study Area, 1920-1960

Source: U. S. Department of Commerce, Weather Bureau, Climate of Michigan by Stations, February 1963

Average annual snowfall variation over the Basin is great due to the effect of Lake Michigan and the prevailing southwesterly winds. Counties on or close to the Lake average 60 to 70 inches a year with maxima as high as 130 inches. Central to eastern counties in the Basin receive an average annual snowfall of only 30 inches.

Length of growing season ranges from 130 to 160 days with as many as 180 days along Lake Michigan. Low-lying lands and particularly organic soils are susceptible to late spring and early fall frosts however.

The Pattern of Drainage

Among the primary drainage systems in Michigan the Grand River Basin system is the second largest. Approximately 5,570 square miles are drained by the Grand and its tributaries. The Basin is egg-shaped with a maximum length of about 135 miles and approximate width of 90 miles.

There are six major tributaries which contribute most of the runoff in the system. These consist of the Flat, Rogue, Maple, Thornapple, Lookinglass and Cedar rivers. Numerous smaller tributaries flow into the main channel along its route, adding to the total drainage of the Basin.

Geology

The geologic formations of the Grand River Basin, like most of Michigan, are of glacial origin. The largest area of till plain in Michigan is found in the Basin.

The Grand River starts in a low swampy area in northern Hillsdale County. Over the river's 300 miles to Lake Michigan, the change in elevation is 460 feet. From Lansing, south to the headwaters, soils are of sandy to clay loams with good to moderate drainage. Moraine, outwash and till plain are evenly distributed

throughout the area. The Lookinglass, Maple and Prairie rivers drain fine textured till plain soils in the central Basin with intermediate to poor drainage characteristics. The Flat, Thornapple and Rogue rivers and Crockery Creek tributaries drain areas that consist of outwash, moraines and till plains similar to the central Basin soils.

Delineation and Characteristics of Land Resource Areas

Land Resource Areas are extensive in size and delineate regions within the United States into areas of similar physical and climatic characteristics. Within each LRA, the soil, climate, geology, vegetation, topography and agricultural development are similar or related.

The Basin includes parts of two Land Resource Areas: (1) LRA 98, the Southern Michigan Drift Plain; and (2) LRA 99, the Erie-Huron Lake Plain.[3/] Seventeen of the nineteen counties, lying wholly or partly in the Basin, are in LRA 98. Gratiot County overlaps into both LRA's. However, since the large majority of that county is in LRA 98, it is classified as being completely within that LRA. The remaining county, Shiawassee--only 30 percent of which lies in the Basin--is in LRA 99.

The portion of LRA 98 in the Grand River Basin is located in south central Michigan and extends from the shore of Lake Michigan part way into the "Thumb Area" of the State. Most of the acreage in the Basin is within this Land Resource Area.

Dairy and general farming are the dominant types of agriculture in the area with specialized poultry, fruit, and vegetable production

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[3/] USDA, Soil Conservation Service, Atlas of River Basins of the United States, Washington, D. C., June 1963.

in the western fringe of the Basin.[4/] There are a large number of part-time and residential farms in the area, particularly near the large urban centers.

The portion of LRA 99 that is in the Basin does not differ significantly in these respects from the remainder of the 11 major counties of the study area. For that reason, a separate classification of soils was not made for the two LRA's in the Grand River Basin.

Soils and Soil Groupings

An inventory of the kinds of soils, including slope and erosion characteristics is available from the Inventory of Soil and Water Conservation Needs (CNI) made in 1958 under the leadership of the Soil Conservation Service, USDA and cooperating agencies. These soils can be grouped into capability or management units which combine soil series, soil types and phases of soil types that are nearly alike in agricultural potential, plant growth, and response to similar treatment and management. A more aggregate grouping of soils frequently used in Michigan is the soil management grouping. These are combinations of soil series and capability units on the basis of soil texture and natural drainage profiles primarily. A soil management group combines all slopes of a given soil.

For the analysis of current and potential crop and pasture production in the Grand River Basin, soil capability units have been combined into seven large management groupings. These large groups were based on the cooperative work at Michigan State University between the U. S. Soil Conservation Service and the Michigan Agricultural Experiment Station. Both agencies use the soil management groups as a basis for recommending conservation and production practices which have a general applicability to the combined soils of a particular management group. Table 1

[4/] For a discussion of the present agricultural economy of the Basin see: The Agricultural Economy of the Grand River Basin, ERS, USDA. May 1964.

Table 1. Significant characteristics of large soil management groupings, Grand River Basin study area 1/

Soil management groups	Relief and drainage	Parent materials and management problems	Native vegetation	Land use and major crops
0a, b, c 1a, b, c	Nearly level to rolling with moderate to poor drainage characteristics.	Developed in clay loam or silty clay parent materials. Problems of soil structure and drainage exist.	Relatively wet and swampy, heavily timbered with elm, ash and soft maple.	Suitable to general cropping when adequately drained if soil structure is maintained.
2a, b	Level to hilly, well to imperfectly drained, poor drainage in depressional areas and natural drainways.	Deep and durable soils developed in loam, clay loam, and silty clay loam drift. Associated wet areas influence size and shape of fields. Slope, erosion and drainage are problems.	Generally hardwood forest consisting of sugar maple, oak, ash, hickory, elm and soft maple.	Dairy and livestock with associated general crops and some cash cropping.
2c	Nearly level to depressional areas which are naturally poorly drained.	Relatively high in organic matter, nitrogen and lime, moisture retentive. Developed in loams, silt loams and clay loams; have high natural fertility but problems of drainage.	Heavily timbered primarily with elm, ash and soft maple.	Generally used for high-value crops such as corn, field beans and sugar beets but suitable for general cropping.

Table 1 continued--

Table 1 (cont.). Significant characteristics of large soil management groupings, Grand River Basin study area 1/

Soil management groups	Relief and drainage	Parent materials and management problems	Native vegetation	Land use and major crops
3a, b, c	Level to hilly with slow to rapid surface drainage.	Surface and subsoils slight to strongly acid, sandy loams with moderate water-holding capacity underlain with sand and gravel in places, water erosion a serious problem in some areas, drainage needed in others.	Largely hardwood forest of oak, hickory, elm, ash and soft maple.	Moderate natural fertility adapted to a wide range of crops, especially potatoes and all types of livestock production. Gravel and sand sources, hilly areas suitable for recreation and forestry.
4a, b, c	Level to hilly and rolling to extremely rough with lakes, swamps and marshes in the basin-like associated areas, surface drainage good to rapid.	Open and loose loamy sands with a finer textured subsoil. In some cases there is loam to silty clay at depths of 18 to 42 inches. Some with seasonally high water tables require drainage. Drouthiness, low productivity and erosion on steep slopes are problems on others.	Hardwood forest of oak, hickory, elm and ash, marsh and short grasses.	Diversity of soils and unfavorable topography result in a wide range of field crops, fruits and special crops. Many hilly areas are unsuitable for farming and are used for forestry, recreation and sand or gravel enterprises.

Table 1 continued--

Table 1 (cont.). Significant characteristics of large soil management groupings, Grand River Basin study area 1/

Soil management groups	Relief and drainage	Parent materials and management problems	Native vegetation	Land use and major crops
5a, b, c	Level to extremely hilly uplands, with some dunes along Lake Michigan, generally well drained, but some poorly drained areas are included.	Mainly deep sands to more than 66 inches, strongly acid, low water holding capacity and low fertility. Level areas respond to irrigation and fertilization, wind erosion is a problem where the soil is tilled.	Hardwood forest of oak, hickory, elm and ash, sedges and short grasses.	Some general cropping, pasture, truck crops, small fruits, second growth forest, public recreation areas and rural residences.
Mc	Level to depressional with poor to extremely poor natural drainage.	Mucks and peats of variable thickness developed from the partial decomposition of plant remains, with water level management, fertility, frost and wind erosion problems.	Marsh and bog vegetation, short grasses, scrubby trees, elm, ash, soft maple, brush and shrubs.	Production of onions, mint, celery, potatoes and truck crops, small acreages of pasture and blueberries where the soil is very acid.

1/ Clarence A. Engberg, State Soil Scientist, Michigan SCS, USDA and Dr. Eugene P. Whiteside, Professor of Soil Science, Michigan State University, assisted in developing this table.

Source: Whiteside, Schneider and Cook. Soils of Michigan, Michigan Agricultural Experiment Station, Spec. Bul. 402, December 1959 and Hill and Mawby, Types of Farming in Michigan, Mich. Agr. Expt. Sta., Spec. Bul. 206, September 1954.

lists in greater detail the general characteristics of the soil management groups included in each large grouping.

Land Utilization and Trends

Historical Development of the Area[5/]

The first permanent white settlements in the Basin were established in the early 1820's in Kent County, primarily by people from New York. Others came later from Pennsylvania, Ohio and the New England states. A similar pattern of settlement followed for the entire Basin. Western counties of the Basin were settled prior to the northern and interior counties which were settled as late as 1850.

A flourishing fur trade was established by the first settlers and the word of low land prices brought a rapid and steady growth in population. Later settlers farmed small clearings in the densely forested study area on a subsistence basis. Basin agriculture followed much the same pattern as did the State. The increase in land farmed was rapid up to the early 1900's as the virgin forests were cut to make way for agriculture.

Land-Use Trends

Land-use trends in the study area have generally followed those of southern Michigan. As reported by the Bureau of the Census, land in farms and farm numbers continued to increase until the middle 1930's when they began a continuous decline (Table 2).

[5/] This section draws upon some of the early soil surveys of the 1920's and 1930's developed cooperatively between the USDA and the Michigan Agricultural Experiment Station. Soil surveys for Barry, Clinton, Eaton, Ingham, Jackson, Kent, Montcalm (1940) and Ottawa counties were used.

Table 2. Trends in major farm land use, Grand River Basin study area

Year	All land in farms	Cropland				All farm woodland	Other land in farms
		Total	Harvested	Pastured	Other		
	Acres						
1929	3,621,727	2,542,528	1,808,086	429,315	305,127	432,228	646,971
1934	3,789,809	2,628,597	1,908,065	465,348	255,184	457,066	704,146
1939	3,746,697	2,653,515	1,802,164	596,920	254,431	345,712	747,470
1944	3,738,342	2,538,773	1,936,596	383,044	219,133	404,312	795,257
1949	3,542,855	2,483,279	1,795,322	415,741	272,216	457,824	601,752
1954	3,403,171	2,421,179	1,803,121	390,787	227,271	425,426	556,566
1959	3,242,901	2,326,360	1,722,838	292,424	311,098	395,377	521,164

Source: U. S. Census of Agriculture

However, cropland in farms increased until the early 1940's before beginning to drop. Average farm size decreased about 20 acres in the late 1800's but began a steady rise with the reduction of farm numbers and consolidation of holdings. Compared with surrounding states, the average farm size throughout Michigan has been considerably smaller due to the large numbers of part-time and residential farm units. By 1960, the average size of farms increased to 130 acres (Table 3).

In 1958, cropland comprised 57 percent of the study area's agricultural land base (Table 4). This was nearly a quarter of all cropland in the State. About 15 percent of the Basin farmland was in forest and woods in 1958. Over the State, however, the relative magnitudes of cropland and forest are the reverse of the Basin. State cropland covered only 29 percent of the inventory acreage while the percentage of forest was nearly 44. For purposes here, cropland was defined to include all land under tillage, in orchard or held temporarily in cover in anticipation of future cultivation such as soil improvement crops, rotation pasture and tame hay. Pasture and range represented land in grass or other long-term forage primarily used for grazing which was less than 10 percent forested. Rotation pasture was not included. Forest and woodland had greater than 10 percent forest cover. All land in farms not classified in the above categories was included in other agricultural land. Urban-industrial and built-up areas of 10 acres of more make up the nonagricultural land use category. Federal land and water areas less than 40 acres in size are part of this category.

Table 3. Trends in farm numbers, size, and farm land, Grand River Basin study area

Year	Farms	Average size	Land in farms	Cropland in farms
	Number		Acres	
1929	36,053	100	3,621,727	2,542,528
1934	40,521	94	3,789,809	2,628,597
1939	39,301	96	3,746,697	2,653,515
1944	36,068	104	3,738,342	2,538,773
1949	32,835	108	3,542,855	2,483,279
1954	29,274	116	3,403,171	2,421,179
1959	25,036	130	3,242,901	2,326,360

Source: U. S. Census of Agriculture

Table 4. Major land use, Grand River Basin, 1958

	Basin		Michigan		Proportion basin item is of state item
	Area	Proportion of land area	Area	Proportion of land area	
	(000 acres)	Percent	(000 acres)	Percent	Percent
Inventory acreage					
Cropland	2,469.3	57.0	10,461.2	28.7	23.6
Pasture and range	376.3	8.7	1,764.7	4.8	21.3
Forest and woodland:					
In farms	667.6	15.4	15,907.6	43.6	4.2
Other	7.7	0.2	322.0	0.9	2.4
Other land	504.3	11.6	3,124.5	8.5	16.1
In farms	222.8	5.1	1,331.2	3.6	16.7
Other	281.5	6.5	1,793.3	4.9	15.7
Total Inventory	4,025.2	92.9	31,580.0	86.5	12.7
Non-inventory acreage					
Federal land	7.0	0.2	2,765.9	7.6	0.3
Urban built-up	281.1	6.5	1,979.2	5.4	14.2
Water areas*	19.7	0.4	167.0	0.5	11.8
Total non-inventory	307.8	7.1	4,912.1	13.5	6.3

Table 4 continued--

Table 4 (cont.). Major land use, Grand River Basin, 1958

	Basin		Michigan		Proportion basin item is of state item
	Area	Proportion of land area	Area	Proportion of land area	
	(000 acres)	Percent	(000 acres)	Percent	Percent
Total Land Area	4,333.0	100.0	36,492.1*	100.0	11.9

Source: An Inventory of Michigan Soil and Water Conservation Needs, 1962

* There are 766.1 thousand acres of inland water areas, 40 acres and larger in Michigan, which are not counted in these definitions. See Land and Water Area, By Counties, 1960, Bureau of Census, Department of Commerce.

SUB-REGION AND BASIN AGRICULTURAL PRODUCTION POTENTIAL

Definition of Region, Sub-Region and Sub-Area

The United States was divided into groups of states approximating ten major water resource regions for purposes of this study and previous river basin analyses by ERS. Only one of these ten regions which includes the four states of Kentucky, Ohio, Indiana and Michigan is of concern in this study. The region has been termed the "Ohio River Basin States" for purposes of identification.

There is a wide range of crops and livestock grown in the region, ranging from concentrations of milk production and specialized crops in the north through feed-grain producing areas in the Corn Belt and the tobacco and grazing sections of the south. With such a variation in production, nearly all crops grown in the United States are represented in this region. On an area basis, the Grand River Basin study area makes up a small part of this region.

The sub-region consists of 42 counties in southern Michigan, which includes the 11-county study area (Figure 2). Counties used in the sub-region are the same as those developed for the Lake States Dairy Study by the Farm Production Economics Division, ERS, USDA. The 42-county sub-region represents the major portion of agricultural production in Michigan. The 42-county area was further divided into five sub-areas to represent particular types of farming. Sub-area 1 consists of counties around the metropolitan area of Detroit, involved in more intensive farming. Sub-area 2 is the cash crop "thumb area," sub-areas 3 and 4 are general

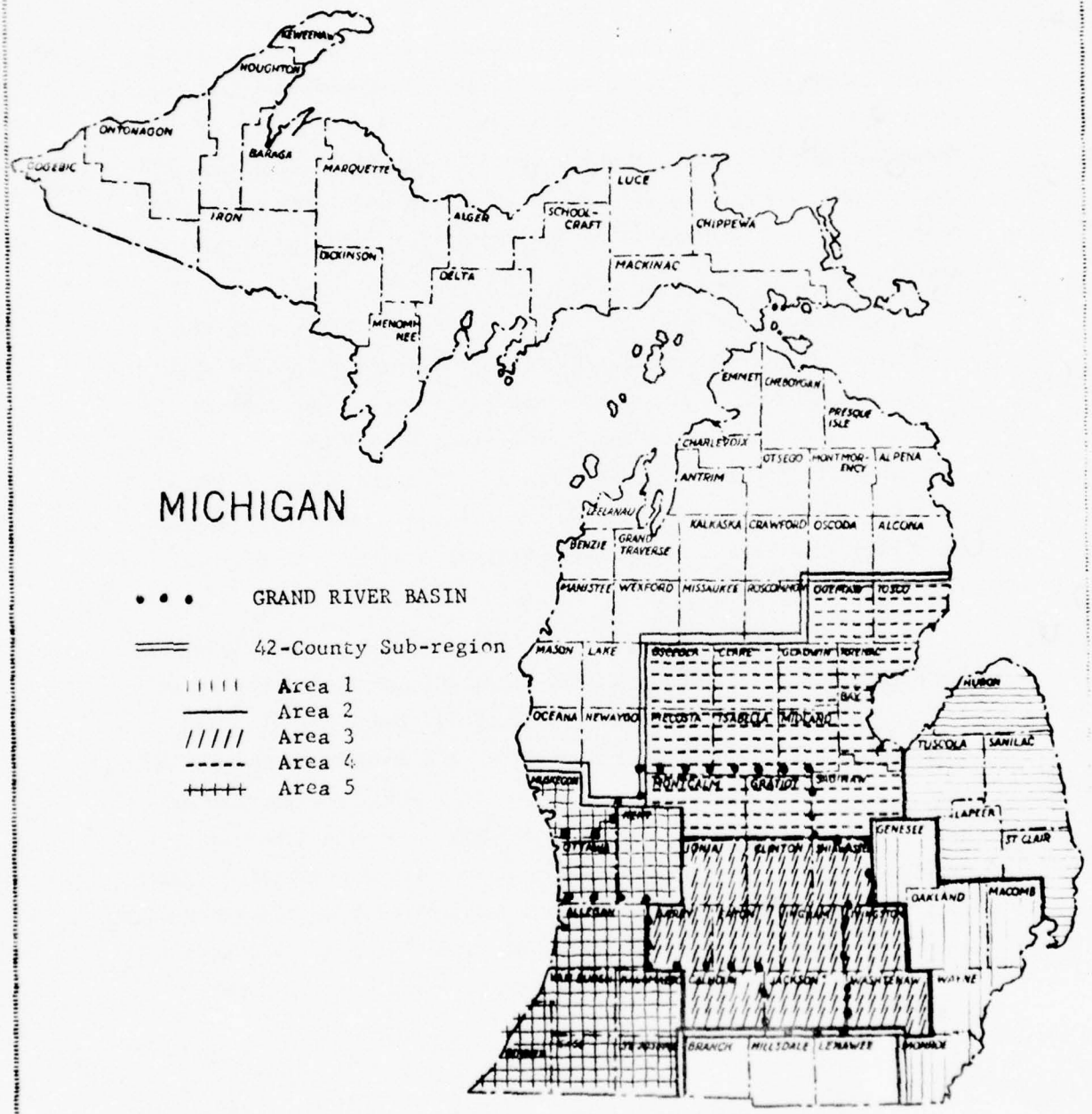

Figure 2. Map of Michigan, 42-County sub-region, Grand River Basin, and five sub-areas

farming and livestock-producing areas in the center of the State, while sub-area 5 includes the counties along Lake Michigan, producing fruit and vegetables.

Agricultural Land Base Available

The agricultural land base was developed from the Inventory of Soil and Water Conservation Needs (CNI) and other soils data developed earlier from this same source by the Farm Production Economics Division, ERS, USDA in conjunction with the Michigan Agricultural Experiment Station. The soils data developed by FPED served a slightly different use and among other things did not include acreages of organic soils and were thus revised somewhat for this study.

The CNI was a nation-wide survey on a sample basis representing two percent of all farmland. Approximately 40 to 48 sample segments of 160 acres each were mapped for the average county. These samples were expanded to represent the total area.

All soils in each of the 42 counties of the sub-region were summarized into the five sub-areas on a type-of-farming basis and converted into soil management groups. The Grand River Basin lies partly in three of the sub-areas. Proportional relationships of the soil management groups existing in the Basin and each of the three sub-areas were developed. They are used later for purposes of allocating production of various crops in each of the sub-areas to the study area. These same proportions are also used in removing acreage from the cropland base for urban and related uses and minor crop production.

Soils in management groups 1, 2, 2c, 3 and M are generally considered well adapted to continuous crop production (Table 1). However, management groups 4 and 5, while capable of growing crops, are not as well adapted to crop production as the other

management groups. They are well suited to the production of forest products. In the soil groups best suited to crop production, 87.3 percent or 2,019,800 acres are currently in that use in the study area while 12.7 percent is used for permanent pasture (Table 5). Also, 450,600 acres or 84.3 percent of the soil groups better adapted to permanent pasture and woodland were in the cropland category and only 15.7 percent in pasture.

Reduction of the Agricultural Resource Base

In determining the available supply of agricultural land to meet future production ofjectives, it was necessary to consider the forces under way which permanently reduce the agricultural resource base. Such factors as farm land required for residential, industrial, commercial, recreation and transportation uses were evaluated in southern Michigan. Regional comparisons were made with the help of data from planning commissions, highway departments, development agencies and regression analyses of changing urban land requirements as population changed by decade.

Projected land-use changes associated with urban-industrial expansion were based on past trends and future population assumptions. Michigan's population was assumed to continue to grow at the same rate as the nation. Census of Population data show that the 42-county sub-region comprised 88.9 percent of the State's population in 1950 and 90.4 percent in 1960, an increase of 1.7 percent for the decade. The same rate was assumed to continue until 1980 and then stabilize. Land requirements were estimated on the basis of acres per 1,000 population increase derived from changes in land area and population developed from Census of Population data. Estimates of the kinds of soils likely to go into urban and industrial uses were made for each county in the

Table 5. Acreages of cropland and pasture by soil management groups, Grand River Basin study area, 1958

Soil management group	Current use		
	Cropland	Pasture	Total
	----------000 Acres---------		
Suited for crop production			
1 abc	66.3	7.6	73.9
2 ab	883.6	92.3	975.9
2 c	275.1	23.3	298.4
3 abc	716.3	117.8	834.1
M c	78.5	51.5	130.0
Subtotal	2,019.8	292.5	2,312.3
Percent	87.3	12.7	100.0
Suited for pasture production			
4 abc	331.6	54.8	386.4
5 abc	119.0	29.0	148.0
Subtotal	450.6	83.8	534.4
Percent	84.3	15.7	100.0
Total	2,470.4	376.3	2,846.7

Source: An Inventory of Michigan Soil and Water Conservation Needs, 1962

Inventory of Soil and Water Conservation Needs and projected to 1975. Based on these analyses projected population needs for land were converted to cropland and pasture acreages and further subdivided into soil management groupings (Table 6). In 1960, the Basin population was approximately 1,094,000. Population is projected to increase to 1.5 million in 1980, 2.1 million in 2000, and nearly 2.9 million by 2020. 6/

The total acreage requirement in the study area averaged 368 acres per thousand person increase in population. Of this total, 337 acres are for urban-industrial and commercial uses, 9 acres for recreation and 22 acres for transportation uses per 1,000 increase in population. A portion of these requirements were assumed to be met from acreages of idle land and pasture. The remainder or 211 acres per 1,000 people was assumed to be met from land now being used as cropland.

Urban impact and minor crop production requirements combine to reduce the cropland base by nearly half a million acres over the 60-year study period (Table 7). These acreages subdivided by soil management group represent the remaining cropland once minor crop production and urban uses have been satisfied. The removal of minor crop acreages from the cropland base will be discussed in a later section.

Not all of the available cropland is suited to continuous growing of certain crops. Row crops are subject to cultivation over the growing season which has a tendency to destroy soil structure and encourage soil loss through both wind and water erosion on certain soils. Consequently, further restrictions were placed on the use of these soils in the simulation model.

6/ Battelle Memorial Institute, The Grand River Basin and Its Economic Future, 1960-2020, Draft, April 1965, p. 117

Table 6. Acreage of cropland by soil management group adjusted for urban impact, Grand River Basin study area, 1958 and projections to 1980, 2000 and 2020

Soil management group	1958	Projected		
		1980	2000	2020
	000 Acres			
1 abc	66.3	63.3	59.6	54.6
2 ab	883.6	847.2	803.0	742.2
2 c	275.1	266.9	255.8	240.6
3 abc	716.3	689.9	656.4	609.6
4 abc	331.6	319.9	304.6	283.4
5 abc	119.0	113.4	107.1	98.1
M c	78.5	74.8	70.7	65.1
Total	2,470.4	2,375.4	2,257.2	2,093.6

Source: Basic soils data from Inventory of Soil and Water Conservation Needs Inventory and the Michigan Experiment Station.

Table 7. Acreage of cropland available for production of major crops, Grand River Basin study area, 1960 and projections to 1980, 2000 and 2020. 1/

Soil management group	1960	Projected		
		1980	2000	2020
	----------000 Acres----------			
1 abc	64.4	62.6	58.3	53.1
2 ab	865.1	839.3	782.3	718.5
2 c	266.6	263.0	249.3	233.2
3 abc	675.7	649.2	569.2	503.3
4 abc	310.2	298.8	274.0	247.2
5 abc	116.8	112.8	106.6	97.6
M c	64.2	58.9	39.3	31.1
Total	2,363.0	2,284.6	2.079.0	1,884.0

1/ Represents available cropland base for production after removal of acreage for urban and related uses and acreage for minor crop production. The removal of minor crop acreages will be discussed in a later section.

Percentages of certain soils which could be used for continuous row-crop production with a minimum soil loss of three tons were adopted. They were placed on the various soil management groups in accordance with the Soil Conservation Service recommended practices to minimize soil losses. These percentages range between 32 and 90 percent currently with no limitation placed on the organic soils. Relaxation of these restrictions were projected along with improved average soil management practices by farm managers for 1980: The range is from 63 percent on management group 1 to 100 percent for group 2c. The range continues to narrow for 2000 and 2020, being 66 to 100 percent and 69 to 100 percent respectively.

Crop Production Technology

The adoption of new technology over the past three decades has accounted for a major portion of increased agricultural output. Widespread use of mechanization, hybrid seed, pesticides, heavier applications of fertilizers, and improved strains of plants and livestock have enabled a steadily decreasing farm population to more than adequately feed an increasing U. S. population. Scientists have developed considerable new technology. But financial and technical assistance programs and educational programs to improve the managerial abilities of farm operators and encourage them to adopt new technology have also been significant. For purposes of this study, production technology includes all output increasing factors other than water resource development and major land use changes.

Future Technological Developments

Undoubtedly existing technology will be more widely adopted to increase crop yields and feeding efficiencies. Only time will tell how rapidly new technologies now in the development stages will be available for general use. In addition, it is pure

speculation to attempt to estimate the possible effects of still unknown but potential technology. Following are some of the more important general developments which are expected to be major contributors to increased production.

Plant varieties will be better adapted to variations in climate, more resistant to diseases and insects, more efficient in their use of water and nutrients, and more compact, with a higher proportion of fruit to foliage. Plants whose seed will germinate and grow under cold soil conditions are being developed. This should result in better use of early moisture and partial escape from hot, dry weather.

The development of additional hybrid varieties is in prospect. For example, the discovery of male sterility in certain small grains will make it possible to develop new hybrids under field conditions.

Closer row spacing and plant spacing within rows will result in better ground utilization and more plants per acre. Heavier applications of high-analysis fertilizers is expected to increase yields.

Widespread use of systemic insecticides and fungicides and specific herbicides will increase yields by reducing pest control problems.

The use of mechanical harvesting of many fruits and vegetables will be widespread and greatly reduce labor requirements. Closely associated will be the development of varieties which are adapted to mechanical harvesting and are designed to mature uniformly at a certain time rather than over an extended period.

Much greater use of performance testing in beef cattle and selection for rapid rates of gain will result from the discovery that this characteristic is heritable. Artificial insemination will

play an expanded role in making superior sires available in dairy, beef and swine production.

Trends toward specialization, increased farm size and scale of operation and improvements in the organization and management of the farm business will continue and become increasingly important in meeting production objectives.

The projections of increased crop production and improved feeding efficiencies for 1980, 2000 and 2020 are approximations of the technology that farmers will adopt based on the assumed conditions. They do, however, represent the best available estimates and should be considered as reasonably obtainable provided scientists continue to develop new technology and farmers continue to adopt it.

Technological Developments for Individual Crops[7/]

Wheat. New developments in wheat production are expected to come from the plant breeding programs. The Hessian fly reduced yields 3 to 4 percent. Resistant varieties are expected to reduce this loss materially. They will permit earlier planting and respond to larger fertilizer applications. Both will increase yields.

Preliminary evidence suggests a possible linkage between seedcoat characteristics and sprout dormancy in the soft red variety which may cause a shift away from the soft white variety now produced.[8/] The production of hybrid wheat is now possible

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[7/] This section draws upon the work of Michigan Agricultural Experiment Station specialists who were developing similar data for the College of Agriculture's "Project 80," a look at Michigan's agriculture in the 1980's.

[8/] Project '80, Crops Committee Phase II Report, March 10, 1965, p. 3.

under field conditions due to the discovery of male sterility. The impact of hybrid wheat on the location of wheat production is uncertain.

Other Small Grains. Increased yields in all grains are expected to come from cross breeding. Beneficial characteristics are expected to be developed such as the short straw varieties of wheat. The hybridization of barley is expected to cause a breakthrough in yields which will allow competition with corn in the production of feed grains on the lighter soils.

Soybeans. Yield improvements in soybeans are not expected to come from intensive plant breeding experiments but through improvements in management. Disease resistant varieties will increase yields. Closer row spacing and the use of herbicides have reduced labor per acre and increased yields by more than 25 percent in experimental work.

Corn. Improved management techniques resulting from efficiencies of larger scale operations and more efficient harvesting equipment will account for much of the projected yield increases of corn. Higher plant populations per acre from closer row spacing, heavier fertilization on better soils, improved hybrids, varieties resistant to rootworm and corn dwarf viruses, better weed control and more timely planting and harvesting are expected to contribute to corn yield increases.

Dry Beans. Development of new varieties suited to direct harvesting methods are expected to increase the quality of the bean and reduce the number of damaged beans thereby increasing the net yield. Labor requirements will also be reduced considerably. Adoption of improved production practices will increase yields by 20 percent through better weed control, heavier planting rates and the use of superior seed which incorporates disease resistance and earlier maturity.

Potatoes. Substantial yield increases are possible in the future for potatoes. Current research on management practices and higher yielding varieties is not receiving much emphasis. However, current research in potato breeding indicates that new varieties with desirable processing characteristics will soon be available for release to growers. The trend toward higher per capita consumption rates of processed potatoes will require more emphasis on quality and uniformity of product. Yield levels will increase considerably due to a shift of production to better quality soils.

Hay and Pasture. Projected increases in the yields of forage crops are expected to come from the continued shift away from clover mixtures to alfalfa and alfalfa mixtures. Better management practices such as heavier fertilization, more frequent cutting, confinement feeding and insect control will bring significant yield increases. Renovation and the use of quality seed and recommend applications of fertilizer will greatly increase permanent pasture yields.

Vegetables. Labor shortages have caused considerable research and development efforts in designing mechanical harvesting equipment for many of the vegetables grown in Michigan. Fresh vegetables probably will continue to be harvested by hand but harvesting for processing is expected to become almost completely mechanized. There will be increased grower acceptance of better cultural practices and higher-yielding improved varieties which incorporate better quality characteristics for processing, uniform maturity and resistance to blights, bolt and rusts. Earlier maturing varieties will be developed that avoid high temperatures during blossoming and the resulting uneven maturity. Chemical soil organism control and rotations of crops will be used to reduce root rot which seriously impairs yield potential.

New genetic discoveries in vegetables are expected to increase yields greatly. The introduction of hypogeal germinating habits

in snap beans will reduce plant damage since the cotyledons stay in the ground when the plant emerges.[9/] A cross between lima beans and snap beans has given the lima bean the early maturing characteristic, and heavier production from new varieties of this cross are expected. Development of new uniformly maturing varieties of cucumbers for once-over mechanical harvesting is almost complete. Anticipated new onion hybrids are expected to raise yields by 25 percent and reduce storage losses by as much as 50 percent due to uniform maturity.

Closer spacing and the complete use of chemical weed control will raise yields. Airplane spraying for insects and diseases now contribute to the almost complete mechanization of carrot production and will be adopted by other vegetable producers.

Fruit. Recent heavy plantings that have been in the non-bearing category will soon be coming into production which will result in yield increases from the newer varieties. Expansions of storage, marketing and processing facilities will also encourage further planting of new orchards and vineyards. Yield increases will come primarily from improved varieties, closer planting on dwarfed root stock, chemical growth regulation and thinning, better training and pruning, improved fertilization with single elements depending on leaf testing for deficiencies, better control of diseases, insects and rodents, and improved soil management and weed control.

Pest control problems are expected to be reduced through the use of systemic insecticides, fungicides and specific herbicides. Mechanical harvesting will be widely used on some tree fruits primarily used for processing. Improved management efficiency will be associated with specialization and increased size of operation. The use of mechanical pruning will reduce labor requirements

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[9/] Project '80, Vegetable Committee Phase II Report, October 15, 1964, p. 3.

materially. Mechanical planting and chemical weed control have reduced the labor requirements in small fruit production and will continue to do so as this technology becomes widely adopted. However, small fruits other than blueberries are not suited to mechanical harvesting methods. Increased production will be almost directly related to increased acreage, which in turn, will depend on the availability of harvest labor.

Projected Crop Yields

Projected yields for all of the potential crops for each soil management group in the sub-region are necessary for the projection model. The development of current rates of production for each of these crops was a first step in evaluating the Basin's agricultural production potential.

Preliminary estimates of soil management group productivity for each of the major crops were made from state-wide data for all five sub-areas individually. These estimates were evaluated by specialists from the Soil Conservation Service and the Michigan Agricultural Experiment Station. Adjustments were made to incorporate intra-State differences among the sub-areas and average weather and farm management conditions. This set of estimates was averaged across all soils of a sub-area for a particular crop.

Michigan Crop Reporting Service data were used to normalize the current yield estimates (Table 8). Normalization is a step whereby current production and acreage data are adjusted to eliminate extremes due to drouths, heavy precipitation, frosts or other abnormal factors. Where yields are steady or fluctuate around a uniform level the current normalized yields approximate the average prevailing during a recent period. Where yield trends are significant, normalized current yields reflect the level of the most recent year. Normalized county average yields were used to raise or lower soil management group yields for the county by a

Table 8. Current normalized crop yields by soil management group, Grand River Basin study area

Crop	Unit	Soil Management Group							Avg.[1/]
		1abc	2ab	2c	3abc	4abc	5abc	Mc	
Wheat	bu.	29	30	35	27	23	15	--	26.5
Corn	bu.	63	62	72	53	45	32	69	56.6
Oats	bu.	50	53	58	45	37	27	--	45.0
Barley	bu.	38	39	48	34	32	--	--	38.2
Soybeans	bu.	23	23	27	21	20	--	28	23.7
Dry Beans	cwt.	11.6	13.7	15.6	10.9	9.9	--	--	12.3
Potatoes	cwt.	--	175	--	188	170	--	240	193.2
Corn Silage	ton	10.6	11.1	14.0	10.0	9.0	6.5	12.0	10.5
Alfalfa Mix.	ton	2.7	2.7	3.2	2.6	2.1	1.3	--	2.4
Other Hay	ton	1.9	1.8	2.1	1.7	1.2	0.9	--	1.6
Cropland Past.	AUD	114	125	145	111	88	55	--	106.3
Permanent Pasture	AUD	--	--	--	--	--	--	--	63

[1/] Simple unweighted average

factor needed to make the soil productivity levels consistent with published data on production. Available data did not permit comparable adjustments for estimated yields of pasture so these yields were assumed to be normal.

The current normal yields by soil management group were used as the base for projecting future yields. Statistical Reporting Service time series data from 1947 to 1963 were utilized in a regression analysis to make a first estimate of future yields in each sub-area. The prediction equation was yield as a logrithmic function of time which tended to add conservatism to adjustments in future yields. However, the preliminary projected yields for each crop in each subarea were reviewed and adjusted by specialists in the Michigan Experiment Station and the Soil Conservation Service according to their knowledge of likely changes. The adjusted projected average yields were then used to project the yields for each soil management group in each sub-area.

Crops are expected to respond differently to new and improved technology as indicated in the previous section (Figure 3).

Production Costs

The development of production cost data was on the basis of current input price levels and relationships. Cost budgets were adapted from the work of Blosser, in Ohio, and specialists at the Michigan Agricultural Experiment Station.[10/] All items of on-farm costs were included with the exception of charges for storage and land. The per acre production costs for each crop and soil were

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[10/] Blosser, R. H. Crop Costs and Returns in West Central Ohio, Ohio Agricultural Experiment Station, Wooster, Ohio, Research Bulletin 909, June 1962.

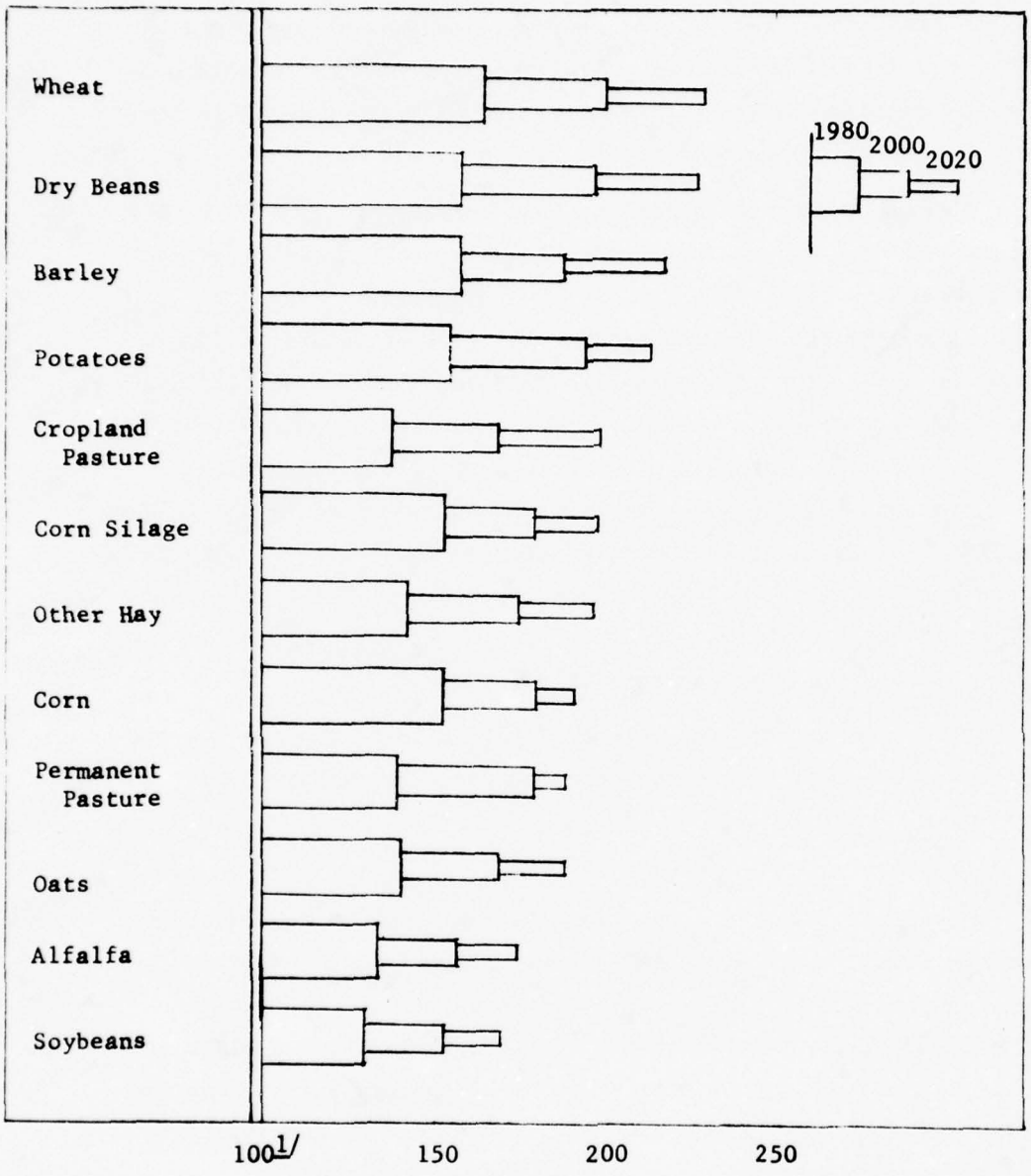

Figure 3. Index of projected yield increases by crop, 1980, 2000, and 2020

1/ 100 represents 1959-61 yield levels.

aggregates of three major types of costs; prehervest costs, harvesting costs and the cost of materials. These costs were developed by applying an hourly charge against the time required to perform each operation. For instance, charges were based on the costs of operating a three-plow tractor and the appropriate equipment for that power source. Labor cost was figured at $1.58 per hour and no differentiation was made between hired, operator and family labor costs.

Preharvesting costs consisted of charges for land preparation, planting and cultivation in general. However, there were additional labor and equipment charges for side dressing with fertilizer and spraying with insecticides and herbicides for certain crops. Charges were made for clipping cropland pasture and permanent pasture. A miscellaneous labor charge was made for minor equipment maintenance, refilling of planter with seed and fertilizer, fueling and greasing of equipment and equipment changing. Preharvesting charges did not change in the projected years but since they were in terms of constant dollars they reflect the costs of future production under the limiting assumptions.

Harvesting costs included the time necessary to harvest the crop and in addition, included the costs of equipment and labor needed to transport the crop to the on-farm storage facility. Off-farm transportation costs were not included in production costs.

Harvesting and materials costs varied over the projection years as yields per acre increased. The cost of materials varied among crops more than did the costs of planting and harvesting. Increased fertilizer use made up the major portion of the change in materials costs. Projected fertilizer requirements were tied directly to per acre yields and the type of soil on which the crop was grown. Application of fertilizer was on a maintenance basis

which provided sufficient plant nutrients to produce the projected yields without depleting soil fertility. Other material costs included such items as lime, seed, spray, twine for hay baling and bags for potatoes.

Assumptions and Limitations

In developing the agricultural production potential for the Basin, crop yields were projected for 1980, 2000 and 2020 based on past results and future implications of current research work. Specialists at the Michigan Agricultural Experiment Station were given a point of departure for yield projections based on ERS analysis of Statistical Reporting Service time series data. The projected yields represent the specialists' evaluation of how rapidly new varieties will be made available to farmers and some judgement of the rate of new practice adoption by farmers. To the extent that these assumptions are not fulfilled, the crop yields will be in error.

Acreage for urban-industrial and related uses were subtracted from the cropland base available for production of major crops. The location of urban related development might not follow the general pattern developed in this study. However, the estimates do reflect the thinking of county leaders concerning local zoning ordinances and the likely direction of future growth.

Marketing and transportation facilities were assumed to be adequate to handle the projected agricultural production. Increases in farm size and purchases of equipment are implied which assumes that credit availabilities, tenure arrangements, the recombination of farms, zoning and taxation policies will not interfere with this transition.

In developing the crop production cost data, the input price relationships existing in 1963 were assumed to hold constant throughout the study period. This implies for instance, that the real cost of fertilizer will remain in the same relationship to the cost of labor over the study period. The study allowed for the use of more fertilizer and capital in the projection years relative to labor, but this was with the knowledge of current input price levels and estimates of future production techniques. The subtlety of this assumption is that changes in the real cost of any of the input items might cause further substitutions in the production process. Should this occur, the location of agricultural production could change.

NATIONAL AND REGIONAL FOOD AND FIBRE REQUIREMENTS

National Requirements

The projected national requirements for food and fibre involve consideration of increasing population, rising per capita disposable income and the associated adjustments in per capita consumption rates of particular foods. Consideration of changes in the export demand for these products also is necessary. Population, income and labor force employment projections of the Economic Task Group of the Ad Hoc Water Resources Council Staff were used in estimating demand for this study.[11/] Additional projections were developed by the Economic and Statistical Analysis Division, Economic Research Service (Table 9).

The population projected for 1980 is 254.1 million, an increase of 73.4 million over the 1960 population of 180.7 million or 41 percent. An additional 104.2 million over 1980 is projected for 2000. By 2020 the population is projected to be 502 million, nearly three times the 1960 level. A larger proportion of the population will be in the working age group by that time. Thus, both the labor force and employment are projected to increase at a greater rate than population. An average level of 4½ percent unemployment was projected over the 60-year period compared with the 1959-61 average rate of 5.7 percent of the labor force.

Per Capita Income and Consumption Rates

Growth of labor force and increased productivity per worker are projected to increase gross national product by 113 percent from 1960 to 1980 or a 51 percent per capita income increase. From

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11/ National Economic Growth Projections, 1980, 2000, 2020, July 1963.

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Table 9. Population, labor force, gross national product, output per man hour, and personal income in 1962 dollars, 1959-61 average and projections for 1980, 2000, and 2020, United States 1/

Item	Unit	Average 1959-61	Medium level projection 3/ 1980	2000	2020
Population	mil.	180.8	254.0	358.0	502.0
Labor force	mil.	73.1	104.0	147.3	206.2
Employment	mil.	68.9	99.8	140.6	196.9
Unemployment	mil.	4.2	4.7	6.9	9.3
Gross national product	bil. $	515.3	1,096.5	2,232.1	4,518.4
--increase over 1960			113%	333%	777%
Output per man hour 2/	$	3.71	6.12	9.71	15.30
--increase over 1960			65%	162%	312%
Gross product per capita	$	2,850	4,317	6,235	9,001
--increase over 1960			51%	119%	216%

1/ Adapted from Table 3, Economic Task Group of the Ad Hoc Water Resources Council Staff, National Economic Growth Projections, 1980, 2000, 2020, July, 1963, p. 14.

2/ Ibid., adapted from Appendix Table 2, p. 21.

3/ The Ad Hoc projections differ slightly from those used by Battelle Memorial Institute but that difference should be considered insignificant.

1960 to 2000 the assumed rate of growth in GNP places the level more than four times that of 1960 while the corresponding increase in per capita income is more than 2 times. By the year 2020, GNP is projected to rise nearly nine times and per capita income by over three times that of 1960. Output per man hour is projected to increase more than three times between 1960 and 2020. The overall increase in per capita GNP is over two times during this period as hours per worker are decreasing. The projected gains are in "real" terms as all GNP values are stated in constant 1962 dollars.

The projected per capita use of major farm products was developed by ERS on the basis of growth in per capita income and the resulting influence on the past trends in consumer tastes and preferences (Figure 4). These projected use rates were compared with studies which statistically developed income elasticities of demand for major agricultural products. They were found to be consistent in view of projected income growth. The resulting consumption patterns reflecting trends in greater consumption of livestock products, fruits and vegetables and lower consumption of cereals were held constant beyond 1980, as consumers were assumed to have sufficient disposable income by that time to purchase the mix of food desired.

Export Demand

Foreign demand for agricultural products is most difficult to project. The trade policies of the United States and the other trading nations are important. Essentially, there are two foreign markets open to the export of U. S. produced food and fibre, the commercial and non-commercial markets. In the commercial markets, the underdeveloped nations with low income represent a significant potential for export. As these nations develop and their per capita incomes rise, a large portion of the increases will likely

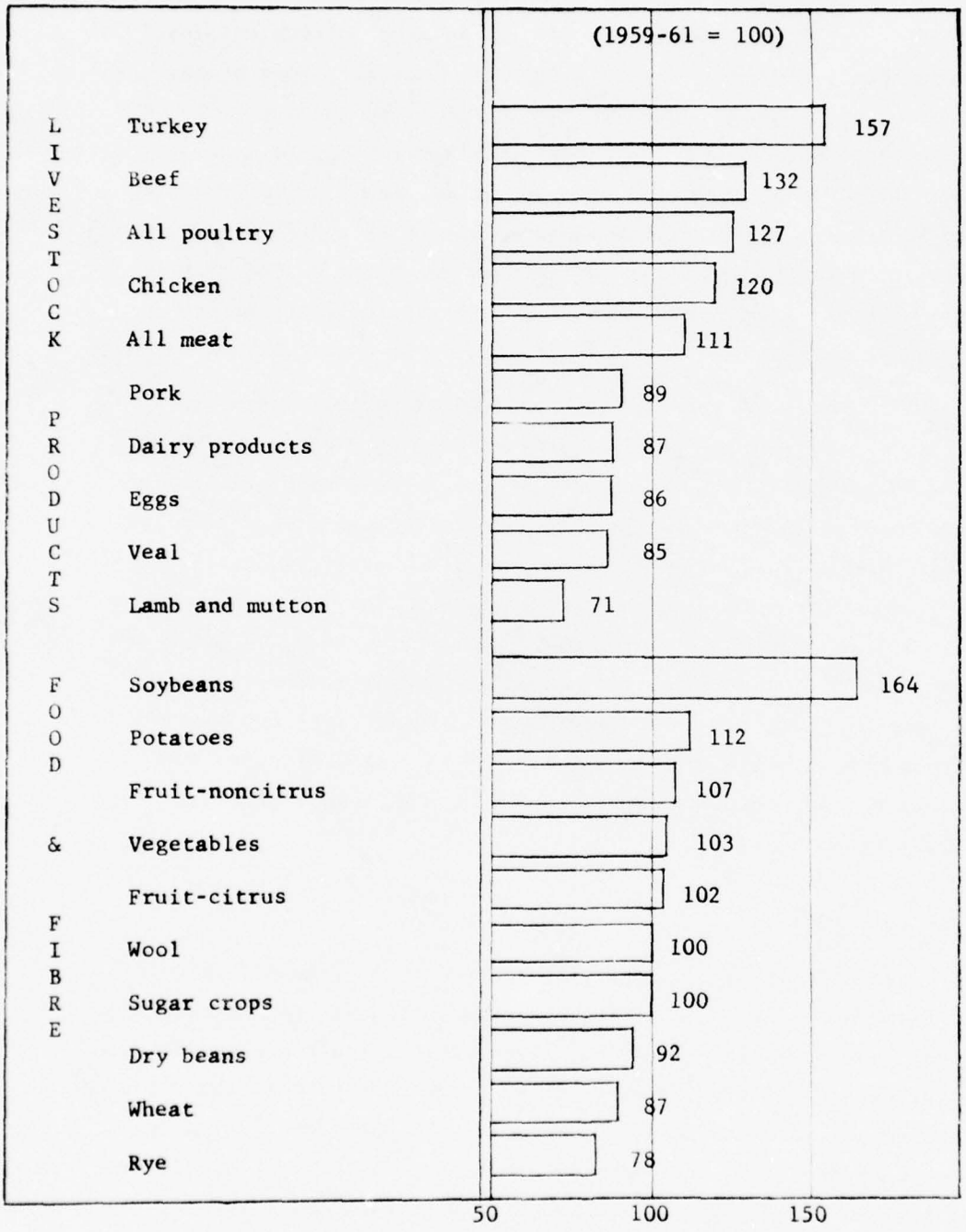

Figure 4. Projected per capita uses of major farm products, 1980-2020, United States.

be spent on food products. If their agriculture is unable to keep pace with their rapid expansion in demand, a potential exists for our exports to meet their needs.

The non-commercial market is supplied through such programs as Public Law 480 which covers gifts, donations and sales for local currency under the Food for Peace program. Other non-commercial undertakings which transfer domestically-produced food and fibre overseas are CARE, Save the Children, and many church-sponsored programs. Policy decisions both in the United States and other countries which alter these programs can have large impacts on total exports and individual commodities. Foreign trade specialists projected net exports to 1980. After 1980 the same absolute net foreign trade was assumed for the rest of the projection period. Underdeveloped countries are expected to provide larger shares of their own food and fibre needs.

Livestock Use and Feeding Efficiencies[12/]

Prior to World War II livestock production was on general livestock farms. Very little specialization existed. War-time conditions provided incentive for specialization. Mechanization allowed larger, more efficient organization and management of enterprises and encouraged the adoption of newer technologies.

Artificial insemination and the selection for certain production characteristics in dairy and meat animals gained acceptance. Nutritional research encouraged the adoption of improved rations and greater attention was given parasite and disease control. Rising health and sanitation standards forced small inefficient operations out of production, encouraged greater specialization and enlarged enterprises to reduce per unit costs of production.

12/ This section draws upon the data developed by Michigan State Experiment Station specialists as part of the College of Agriculture's "Project 80," a look at Michigan's agriculture in the 1980's.

Projected livestock feeding efficiencies were based on this past experience and expected developments in the areas of nutrition, breeding, and management (Figure 5).

Beef and Veal. Grain feeding of cattle has expanded in Michigan in recent years and is expected to double by 1980. Major breakthroughs in nutrition are not expected but the composition of beef produced and management of the beef enterprise will improve feeding efficiency. Dairy cattle comprise a high proportion of all beef produced in Michigan. The composition is expected to change due to an absolute decrease in dairy cattle numbers and a more than three-fold increase in beef cow numbers.[13/] Calf-crop percentages will increase and overall numbers will expand since most State-produced calves will be fed-out in Michigan and there will be some in-shipments. Selection for rapid rates of gain and beef type plus improved disease and parasite control and the correction of nutritional deficiencies will have an impact on feeding efficiencies. Specialization through larger feeding operations will improve feeding techniques and avoid wastage.

Sheep and Lambs. Improved feeding efficiencies in the subregion for sheep and lamb production are expected to come from a change in kinds of sheep fed. Lamb and mutton marketings have declined over the past two decades in Michigan, more than for the United States. Lamb feeding trends are not different from national trends however. Ewe flocks will continue to decline. In-shipments of feeder lambs are projected to increase considerably and have a much higher feed conversion rate than do sheep. Lambs produced in the State will be kept on feed until marketed and will reach market weight sooner. Controlled estrus research will make

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[13/] Project '80, Summary of Phase II Papers, March 15, 1965, p. 4.

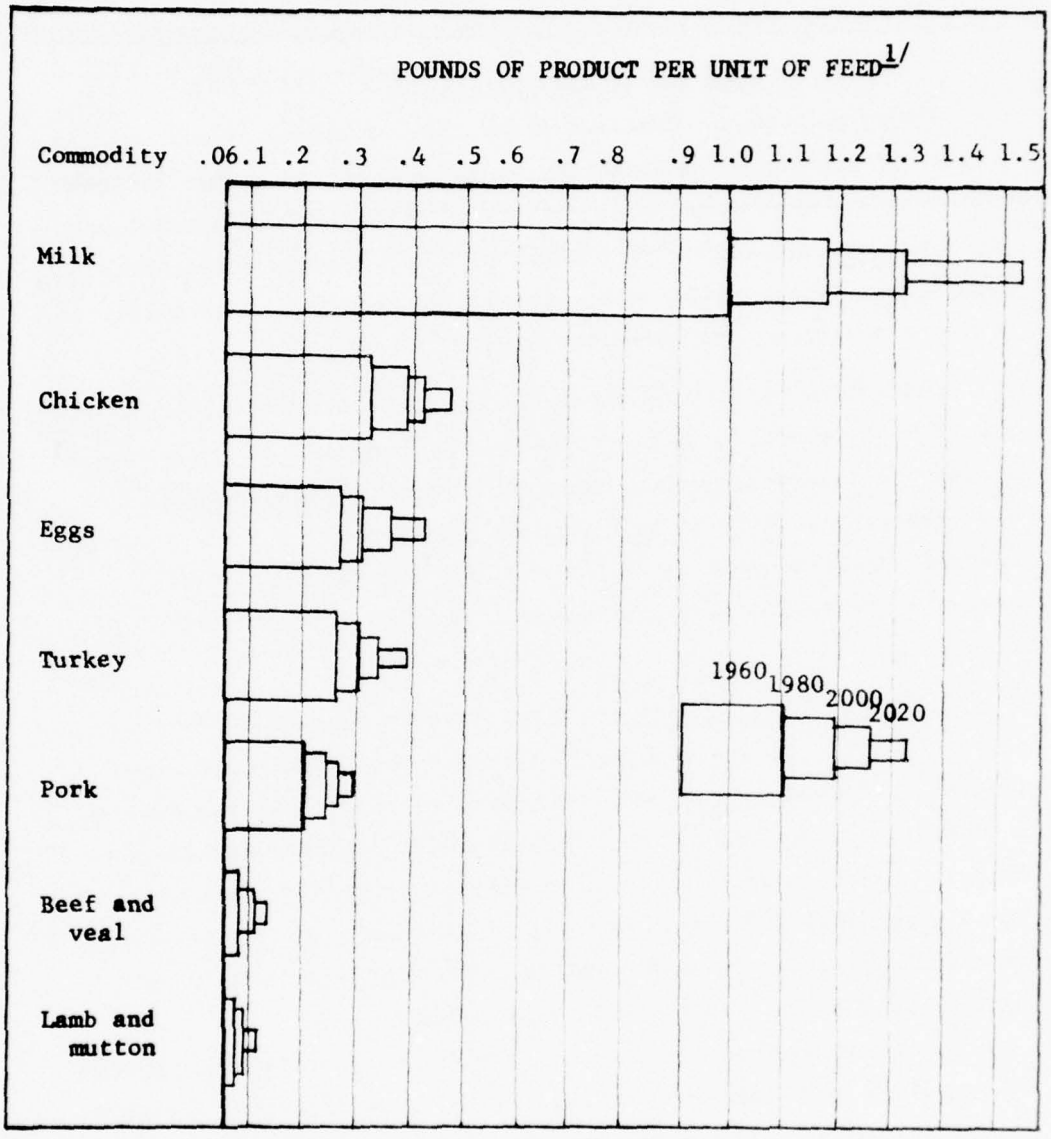

Figure 5. Pounds of product from one feed unit, Grand River Basin study area, 1960 and projections to 2020

1/ A feed unit is considered to be equivalent to one pound of corn in this study.

it possible to obtain two lamb crops per year which would reduce the feed charge for ewe maintenance per lamb. Improved management will result in larger lambs and a higher percentage lamb crop.

Pork Production. Contract marketing and narrow profit margins will force producers to intensify management and adopt new technologies at a faster rate. Hog raisers will become more specialized, some only raising feeder pigs while many others only feed them. Confinement raising will be widely adopted reducing pasture requirements to a minimum and improving feeding efficiency.

Controlled estrus, multiple farrowing, control of environment and the use of artificial insemination will become widespread increasing the quality of animals and improving rate of gain. Closer attention will be paid to herd health and the control of internal parasites and earth-borne diseases. The use of trace elements and antibiotics in feeds will improve general nutritional levels.

Milk Production. Feed grain and protein supplement feeding of dairy cows will be intensified to increase per animal production levels. Greater reliance will be placed on record keeping for selection purposes and critical culling will greatly increase herd averages. Artificial insemination will be utilized almost completely and will facilitate more rapid increases in the genetic potential of future animals. Maintenance requirements as a percentage of the total ration will be reduced as production levels climb, increasing feed efficiency. Dry lot or storage feeding will be practices on a year-around basis by the more efficient managers of the larger but fewer herds expected in the State.

Poultry and Eggs. Anticipated future developments in feeding, breeding and management of poultry and egg production were incorporated in the projections. The complete mechanization of egg

production will reduce feed wastage. Intensive culling measures will eliminate non-layers and maintain high flock health. Breeding for egg-type, smaller body size, higher production and the elimination of dual-purpose hens from commercial laying flocks will increase egg production per unit of feed fed. Developments in nutritional research will provide better balanced rations, new feed additives and solve nutritional problems related to deficiencies which may be closely associated with persistent disease problems. Specialization in the production of started pullets will reduce early death losses due to improved management techniques.

Broiler production is under a competitive disadvantage in Michigan because of high labor and housing costs compared to southern states. Sustained production will be possible only under improved management and specialized large volume operations which will encourage lower feed consumption per unit of production. The same nutritional improvements seen for egg production also apply to broilers.

Turkey production in Michigan is concentrated among a few operators and is highly integrated.[14/] The adoption of new technology and the incorporation of nutritional developments into feeding rations will therefore be more rapid than in less specialized enterprises. Average size of market turkeys will decrease somewhat as consumer preference for lighter weights and year-around use has an influence. Feeding efficiency will improve as new faster-growing strains of turkeys are fed to lighter weights.

Current National Production

More than 28 billion pounds of beef and veal are currently produced in the United States (Table 10). Production of dairy

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[14/] Poultry Committee Project 80 Report, p. 11

Table 10. Production of major farm products, United States, 1959-61

Item	Unit	1959-61
Beef and veal	Mil. Lbs. Live Wt.	28,206
Lamb and mutton	Mil. Lbs. Live Wt.	1,658
Pork	Mil. Lbs. Live Wt.	20,564
Chicken (ready to cook)	Mil. Lbs. Live Wt.	7,571
Turkey (ready to cook)	Mil. Lbs. Live Wt.	1,540
Milk	Million Lbs.	121,164
Eggs	Million	64,993
Wheat	Thousand Bushels	1,185,533
Rye	Thousand Bushels	28,143
Soybeans	Thousand Bushels	597,600
Sugar beets	Thousand Tons	17,047
Dry beans	Thousand Cwt.	18,710
Potatoes	Thousand Cwt.	258,230
Vegetables	Thousand Cwt.	416,640
Fruits, citrus	Thousand Tons	7,723
non-citrus	Thousand Tons	8,098

Source: Economic Framework Investigation Section, River Basin and Watershed Branch, ERS.

products, in terms of milk equivalents, exceeds 121 billion pounds annually. Although the production of milk is several times that of beef and veal, current trends in the consumption of each are bringing production of the two closer together. Production of pork is nearly twice as great as all other remaining meat products.

Major food grain production in the United States is concentrated among wheat, soybeans and rice. The three account for over 107 billion pounds of product. More than two times as much sugar is currently produced in the form of sugar beets than from cane crops. Citrus and non-citrus fruit production exceeds 31 billion pounds annually with slightly more than half from non-citrus sources.

Projected Changes from the 1960 Production Requirements

Red meat production is expected to increase nearly 50 percent by 1980, primarily due to the increased per capita consumption of beef (Figure 6). With no further adjustments assumed in per capita consumption rates past 1980, and large increases of population, the increases over 1960, are 111 percent by 2000, and nearly 180 percent in 2020. Requirements for poultry items such as chicken and turkey increase faster than the growth of population. Turkey needs were assumed to increase even faster than chicken with nearly a 130 percent rise by 1980, and over 315 percent by 2020.

Approximately a 30 percent increase in cereal grains over the 1959-61 production will be needed by 1980, somewhat less than the growth in population due to the expected decline in per capita consumption. With the per capita consumption stabilized after 1980 and the projected increases in population, requirements for cereals for 2000 and 2020 are tied closely to the growth in population. Milk and eggs will continue their downward per capita use until 1980, and then follow the increase in population similar

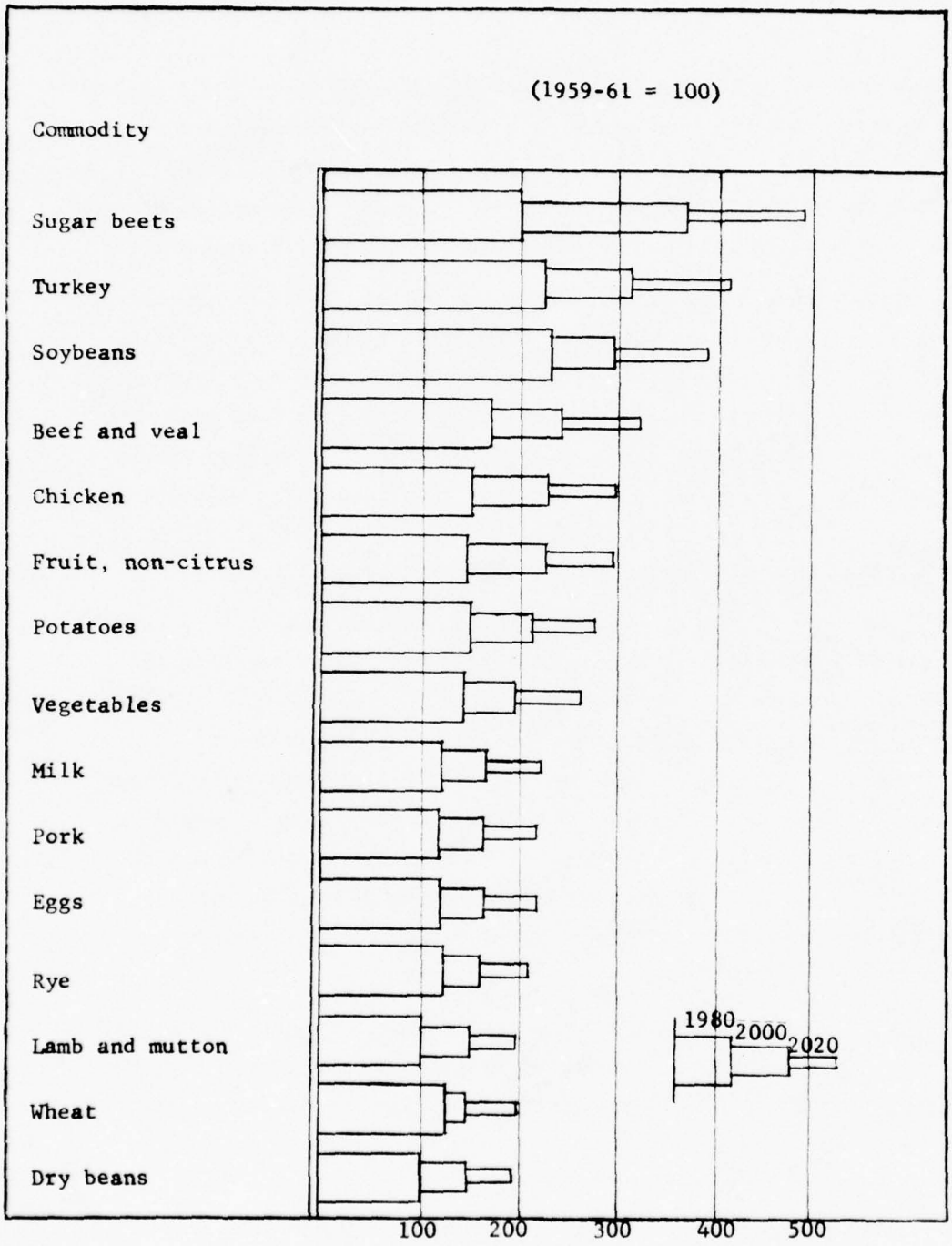

Figure 6. Projected domestic and foreign requirements for major farm products, United States

to cereals. Fruits, vegetables and potato requirements are projected to exceed the rate of population growth. An increase of 134 percent in soybeans will be required by 1980 to meet the rapid growth in demand for that oil crop. Soybean needs are projected to nearly double by 2000 and almost triple in 2020.

In general, the increased requirements for livestock products exceed those for most crops. This is a reflection of changing consumer preferences as per capita incomes rise and the quality of the diet is improved. Important also is the assumption that there will be a marked improvement in the efficient conversion of feed into livestock products. The end product of these efficiency gains is that feed grain production does not need to increase at as fast as rate as livestock to supply the necessary feed.

Regional Allocation

Allocation Procedure to Regions and Sub-Regions

Annual Statistical Reporting Service data from 1939 to 1962 were compiled for each major crop and livestock item in the United States. These compilations were based on the ten major water resource regions of the nation and were used in projecting the regional allocation of national food and fibre requirements. The trends evident were tempered by the knowledge of commodity specialists concerning comparative marketing and production advantages among regions. A percentage share of the total U. S. requirement was projected for a particular commodity in each region.

These projections are intended to serve as guidelines and are subject to the limitations of the assumptions made. They are, however, the best available estimates short of a detailed nation-wide study. They should prove helpful in evaluating the need for future water resource development.

The percentage shares of national food and fibre requirements allocated to the region were further disaggregated to the sub-regional level. The sub-region produces a major portion of Michigan's agricultural commodities. Statistical Reporting Service data over a 17-year period provided the production trends by commodity which were compared with the regional and national production for purposes of defining an historic sub-regional share. Data for the State of Michigan and the region were used in determining intra-regional trends in production. Experiment Station specialists were consulted for their judgements on future shifts in production levels for the State. These data were used in deriving a share of the regional production for the sub-region for the 1980-2020 projection period.

Changes in Regional Production Requirements over 1960

The previous section discussed the allocation procedure for distributing national requirements to the Ohio River Basin States and making projections of the 1980 regional shares of each commodity. A discussion of some of the significant items in the regional trend data follows.

Beef and Veal. The production of beef and veal has increased absolutely in the region but relative to other areas of the nation there has been a steady decline in percentage share (Figure 7). This is primarily due to the trend toward large specialized feed lot operations in the western Corn Belt States, eastern Great Plains and California.

Lamb and Mutton. The decline in lamb and mutton production reflects some of the changing consumption patterns associated with rising per capita incomes and the shift toward higher consumption of beef and certain poultry items (Figure 7). Regional trends followed those of the nation but at a faster pace resulting in a

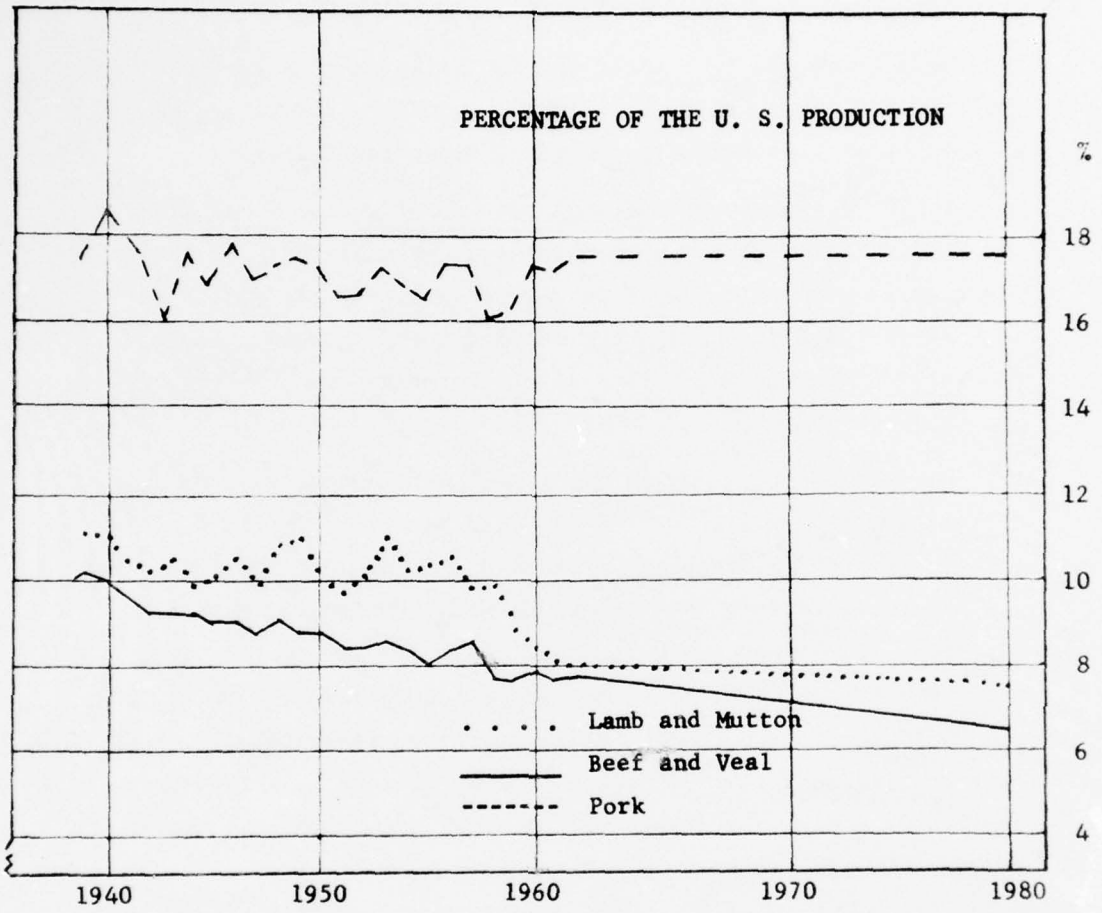

Figure 7. Regional production of meat animals with projections to 1980

Source: Appendix Table 1

somewhat erratic although definite loss of national share. The 1980 projection of 7.5 percent of national requirements reflects the slowing down of the past trend and the belief that farm flocks and smaller feed lot operations will be responsible for a larger proportion of lamb and mutton production in the future.

Pork. U. S. pork production over the last two decades has remained relatively constant, increasing only slightly to supply the growing population but at a slowly declining per capita rate (Figure 7). The regional share of United States production was set at 17.5 percent which is a slight increase over the past 20-year average share.

Dairy Products. The production of dairy products, which is primarily fluid milk in the region, has been tied fairly closely to major subregional markets (Figure 8). Following the Second World War returning veterans settled in the heavily industrialized cities of the region where job opportunities were better than average. Favorable price relationships, economic good times, and the "baby boom" encouraged greater increases in fluid milk production regionally than nationally. The regional share began to decline following the Korean War as other areas increased their dairy production relatively. Technological developments in the marketing of whole milk in non-fluid form will tend to favor lower-cost producing areas. On this basis the regional share was projected at 13 percent by 1980.

All Chickens and Eggs. Poultry production decreased substantially in the last ten years both absolutely and in regional share (Figure 8). This was due to a shift of broiler production to the south and consolidation of laying flocks into large specialized egg-producing units of many thousand birds each. Regional share is projected to decrease even further and reflects primarily laying

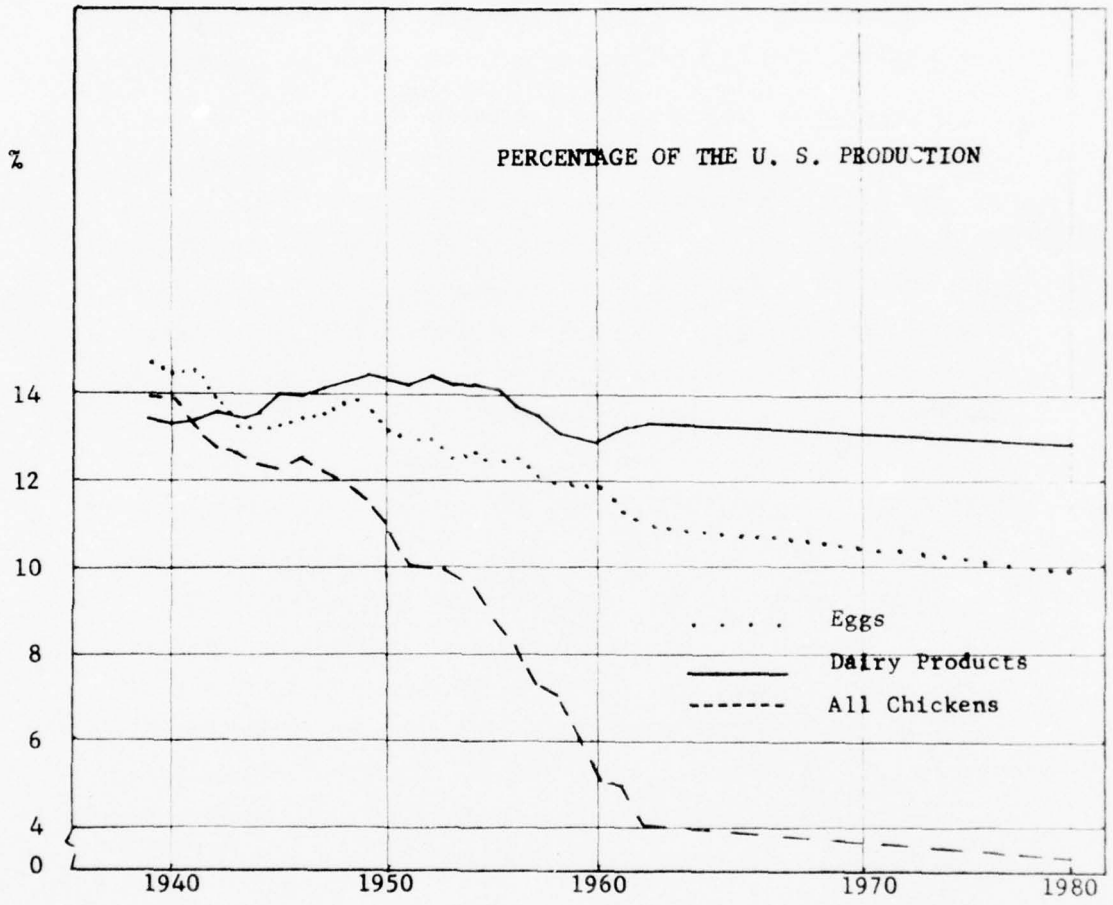

Figure 8. Regional production of dairy and poultry products with projections to 1980

Source: Appendix Table 1.

flock numbers necessary to satisfy regional egg production requirements. The production of eggs regionally has held fairly steady while national production has increased with population growth. This downward trend is projected to continue but at a slower rate.

Feed Grains. Historically the region has been a surplus feed grain producing area. The production of food grains, corn, oats and barley, regionally has been highly erratic due to the fluctuations of its components (Figure 9). However, the regional trend has been steadily upward as a percent of U. S. production. This reflects the increasing share of corn, which is the major component. Oats has decreased in absolute terms. Both of these commodities are projected to increase by 1980, due to yield advantages and livestock-feed demands. Barley is such a small portion of the total that the decline in regional share is insignificant.

Wheat. Regional production of wheat has tended to rise steadily with population growth over the past 20 years (Figure 10). However, the regional share of U. S. production has fluctuated widely as has U. S. production due to favorable and unfavorable weather conditions in the Great Plains. The Great Plains States are expected to provide an increased share of U. S. needs and this is reflected in a reduced regional share of 8 percent by 1980.

Non-Citrus Fruit. The regional share of non-citrus fruit production has been quite irregular although steadily upward. The irregularity is associated with late spring freezes which influence the yield from trees in blossom. Regional share is projected to increase to 9.5 percent of U. S. production by 1980, which is a continuation of past trends (Figure 10). Orchard sites require good air drainage and a moderated climate which the Great Lakes provide this region.

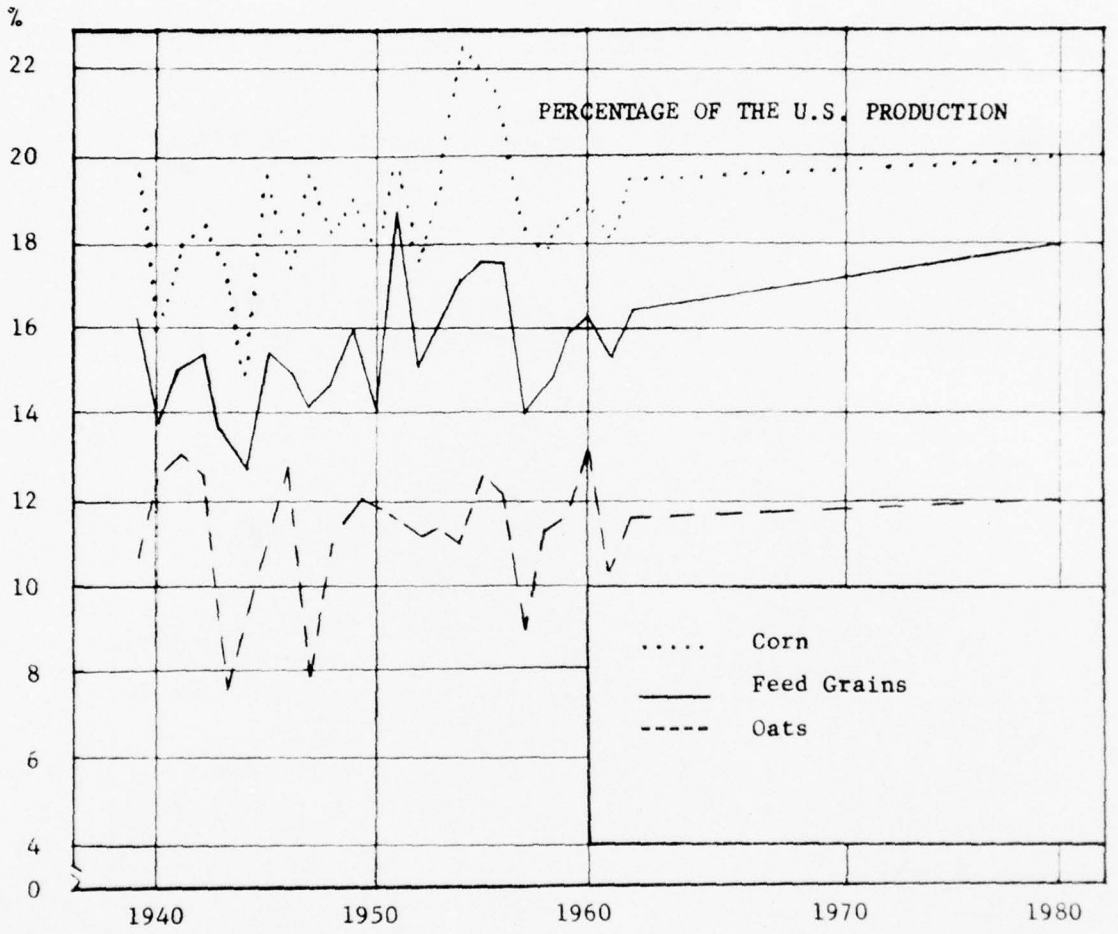

Figure 9. Regional production of feed grains with projections to 1980.

Source: Appendix Table 1.

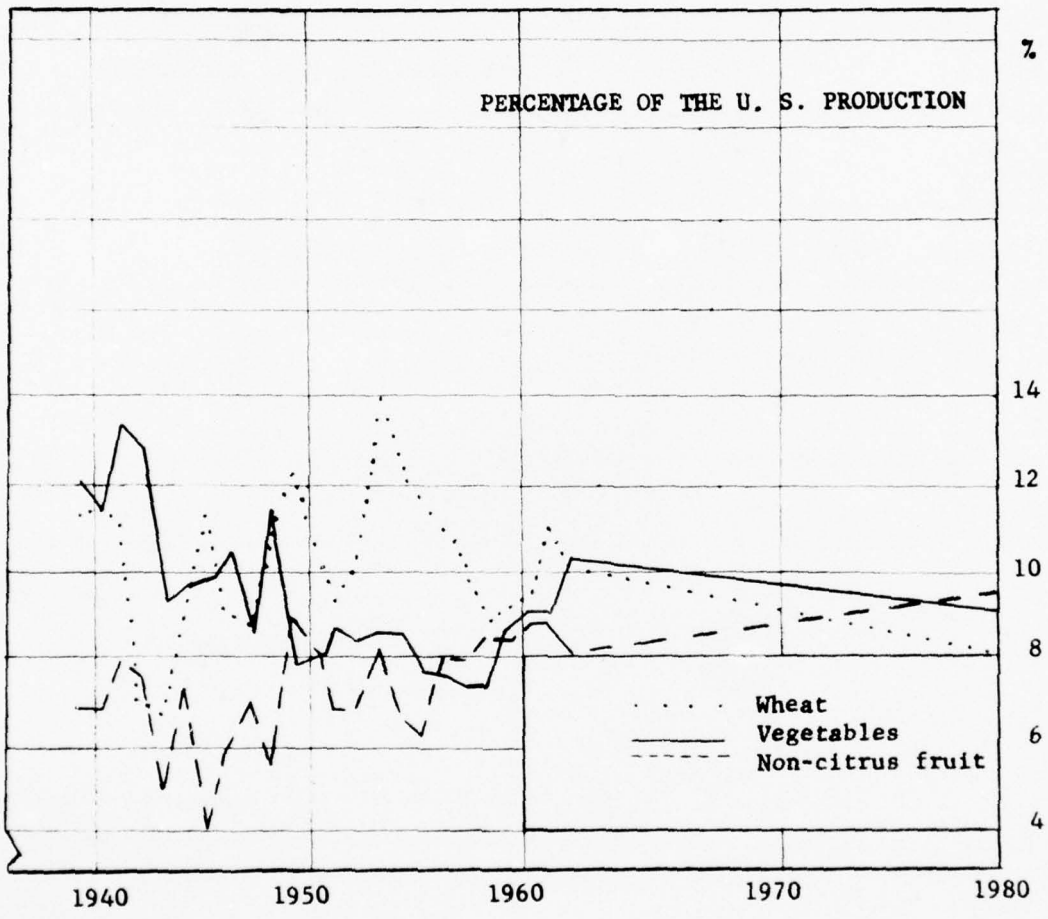

Figure 10. Regional production of wheat, fruits and vegetables with projections to 1980

Source: Appendix Table 2

Vegetables. U. S. production of vegetables, contrary to that of fruit, has doubled over the past two decades due to major improvements in the marketing of the commodities in both the fresh and processed form. Recent technological improvements in varieties which are adapted to freezing and canning have caused shifts in production to areas where processing plants have located. This has favored the West Coast which now supplies the U. S. with winter vegetables and a large portion of the processed demand. Under this competition regional vegetable production has been highly price responsive and the regional share has declined. This decline is projected to level off and the 1980 share is estimated to be 9.0 of the national total (Figure 10).

Dry Edible Beans. Dry bean production, primarily the navy pea bean, has begun to concentrate in the region--mainly in the southern half of lower Michigan. Per capita consumption of dry beans has fallen with rising incomes and accounts for the slow but steady rise in total production over the last two decades. Regional production has, however, shown a greater rate of increase and reflects an overall trend which is strongly upward. National needs will be only slightly higher in 1980 due to declining per capita consumption rates but the shift in production toward Michigan will raise the regional share to 42 percent or 25 percent more than the 1960 production level.

Changes in Sub-Regional Production Requirements

Generally the same changes which were discussed under the section on national projections and their allocation to the region hold true for the sub-region (Table 11 and Figure 11). This section will therefore concentrate on the changes in feed crop requirements within the sub-region due to the projected increases in livestock and livestock products.

Table 11. Combined subregional allocation of total domestic and foreign requirements for major farm products

Item	Unit	1959-61
Beef and veal	Mil. Lbs. Live Wt.	372.2
Lamb and mutton	Mil. Lbs. Live Wt.	17.2
Pork	Mil. Lbs. Live Wt.	213.8
Chicken (ready to cook)	Mil. Lbs. Live Wt.	37.9
Turkey (ready to cook)	Mil. Lbs. Live Wt.	18.2
Milk	Million Lbs.	3,998.4
Eggs	Million	1,299.9
Wheat	Thousand Bushels	27,267.7
Rye	Thousand Bushels	619.2
Soybeans	Thousand Bushels	4,183.2
Sugar beets	Thousand Tons	1,108.1
Dry beans	Thousand Cwt.	6,585.9
Potatoes	Thousand Cwt.	5,681.1
Vegetables	Thousand Cwt.	11,665.9
Fruit, non-citrus	Thousand Tons	380.6

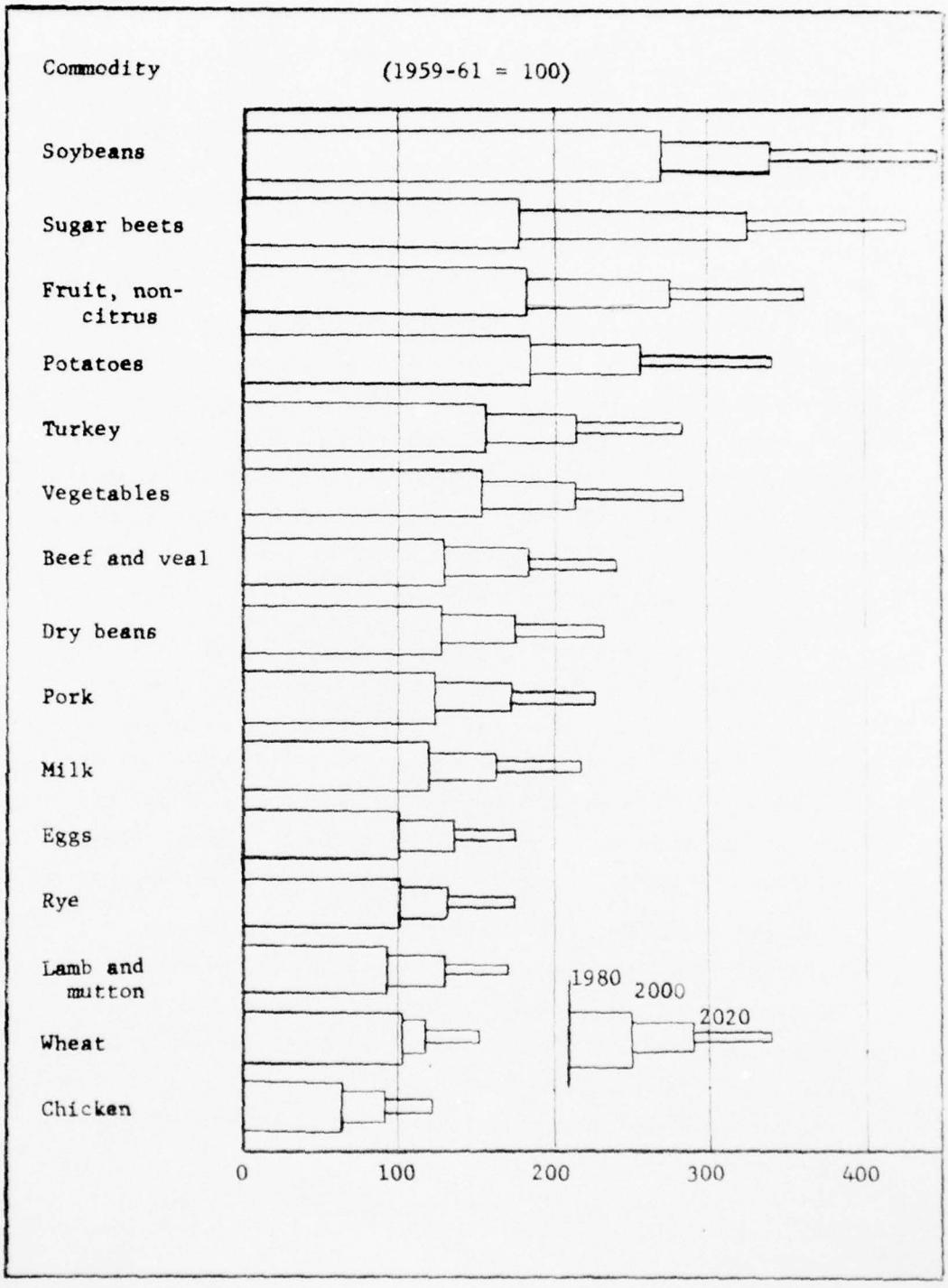

Figure 11. Projected subregional allocation of total domestic and export requirements for major farm products

Two factors are important in the projection of requirements for feed crops: (1) expected requirements for livestock and livestock products, and (2) the combined efficiency with which feed is converted into these products. This section presents the projected livestock product requirements. An earlier section outlined the projected feeding efficiencies. These were combined to develop the projected feed crop requirements for 1980, 2000 and 2020. Historically, Michigan has been a large surplus producer of feed grains and roughages. Feed grain production has been about 40 percent in excess of needs and roughages about 24 percent extra. These relationships were maintained in the projections and added to the requirements needed to produce the projected livestock products. This follows from the slight increase in feed grains projected for the "Ohio River Basin States" (Appendix Table 1 and Figure 8).

Projected changes in feed requirements over the 1959-61 normal requirements are about the same for 1980, 21 percent more by 200 and 35 percent more in 2020 (Table 12). The unchanged requirement for 1980 is a combination of improved feeding efficiencies and a lower national share of certain livestock products for the sub-region than existed over the 1959-61 period. A "feed unit" is considered to be equivalent to one pound of corn in this analysis.

The total quantity of various types of feed grains and roughages required in the projection years was derived for the various crops based on livestock feed ration composition. Most recent feeding relationships for the United States were utilized.[15/] Adjustments were made in these relationships to make them conform with the Michigan experience and to incorporate such trends as were

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15/ Livestock-Feed Relationships, 1909-1963, ERS, USDA, Statistical Bulletin No. 337, November 1963 and subsequent issues of the same series.

Table 12. Sub-regional product requirements, feeding efficiencies and feed unit requirements for livestock and livestock products, 1959-61 and projections to 2020 1/

Item	Product requirements			
	1959-61	1980	2000	2020
	million lbs.			
Beef and veal	372.19	477.26	680.54	900.07
Lamb and muttom	17.24	15.75	22.31	29.51
Pork	213.76	261.27	364.42	481.97
Milk	3,998.41	4,707.84	6,506.98	8,605.98
Chicken	37.86	23.40	34.95	46.23
Turkey	18.17	28.00	38.78	51.29
Eggs	1,299.86	1,245.28	1,731.95	2,290.66
Total	5,957.49	6,758.80	9,379.93	12,405.71

Table 12 cont.--

Table 12 (cont.). Sub-regional project requirements, feeding efficiencies and feed unit requirements for livestock and livestock products, 1959-61 and projections to 2020 1/

Item	Feeding efficiencies 2/				Feed units required 3/			
	1959-61	1980	2000	2020	1959-61	1980	2000	2020
	feed unit				000 tons			
Beef and veal	11.5	10.5	8.8	7.2	2,140	2,506	2,994	3,240
Lamb and mutton	13.0	12.0	10.0	8.2	112	94	112	121
Pork	4.6	4.0	3.7	3.3	492	522	674	795
Milk	1.0	.85	.75	.65	1,999	2,001	2,440	2,797
Chicken	3.0	2.5	2.3	2.1	57	29	40	46
Turkey	3.7	3.2	2.9	2.55	38	50	56	65
Eggs	3.6	3.1	2.7	2.3	2,339	1,930	2,338	2,634
	--	--	--	--	7,177	7,132	8,654	9,698

1/ The 1959-61 average represents normalized production.

2/ Number of feed units required to produce one pound of livestock product.

3/ Computed from livestock product requirements and feeding efficiencies.

either underway or expected to occur. Concentrates were projected only for grains under the assumption that high protein and by-product feeds would be purchased and generally not produced on farms in the sub-region. Most of the high protein requirements for feeding are reflected nationally in the per capita utilization of soybeans and cotton. The projected share of national soybean production thus partially accounts for this segment of concentrate feeds. Grains were divided into corn, oats and barley. The trend away from oats and barley in favor of corn was assumed to continue. In addition, the trend toward more grain feeding and less roughage also was assumed to continue. Shifts underway in roughage feeding favor corn silage and high moisture hay fed under confined conditions; thus, pasture requirements are reduced.

Reservation of Acreage for Minor Crops

Acreages of minor crops in the sub-region were projected separately. For the purposes of this study the minor crops consisted of fruits and vegetables, small fruits, minor small grains, hay crops cut for seed, sugar beets, mint and miscellaneous other crops. Of these fruits, vegetables, and sugar beets were the significant acreages (Table 13). Estimates of the requirements for fruit, vegetables and sugar beets were derived from the sub-regional allocation for these crops. Rates of production per acre were projected for these crops and the acreage required to meet these commitments determined. The acreage of small fruits (raspberries, blueberries and strawberries) was tied to population growth through relationships developed from historical data. The other minor crops were grouped into one category and a constant acreage reserved over the study period which allows increased production and substitutional adjustments to market conditions within this grouping.

Table 13. Acreage of minor crops in the Grand River Basin study area, 1960 and projections to 1980, 2000 and 2020[1/]

Soil management group	1960	Projected		
		1980	2000	2020
	----------000 acres----------			
1 abc	1.9	.7	1.3	1.5
2 ab	18.5	7.9	20.7	23.7
2 c	8.5	3.9	6.5	7.4
3 abc	40.6	40.7	87.2	106.3
4 abc	21.4	21.1	30.6	36.2
5 abc	2.2	.6	.5	.5
M c	14.3	15.9	31.4	34.0
Total	107.4	90.8	178.2	209.6

[1/] Minor crops considered were fruits, vegetables, small fruits, minor small grains, hay crops cut for seed, sugar beets, mint and other crops.

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Acreage of mint crops, following past trends, was reduced to zero by 1990, due to the soil-borne disease problems of this crop and the extremely high cost of corrective measures.

Assumptions and Limitations

National needs for food and fibre were developed using an estimated quantity of net foreign export for the projection years. Decreases in net foreign export because of an unfavorable political atmosphere affecting foreign trade in most cases would not cause much of a problem. Foreign trade is a small proportion of the total future agricultural requirements in general. However, certain commodities such as wheat and soybeans are very important. On the other side, if the United States were to become involved in feeding a much larger portion of the world population, projected national production needs could be short.

The assumed feeding efficiencies in this study are based on past trends and developments in nutrition, breeding and management of livestock enterprises. If they are too conservative, more land will be used to produce food and fibre than is actually needed. On the other hand, if the assumed feeding efficiencies are too optimistic, more land for feed grain production might be needed.

Projected regional allocation of national requirements on a share basis were developed through analysis of past trends. If these trends do not persist, sub-regional shares may be inaccurate.

Minor crop acreage projections were made in groupings such as fruit, vegetables and minor agricultural crops. The procedure does not consider changes in the component make up of these aggregates or the possibility that one or more of these enterprises may go completely out of production in the future. The production and acreage of these aggregates were projected and the agricultural

land base for major crops was reduced accordingly. Errors in this procedure would cause only slight adjustments in total cropland use.

CROPPING AND LIVESTOCK PRODUCTION PATTERNS

Basin Cropping Patterns

Production for the 11-county study area was derived through the use of the economic budgeting model which simulates the actions of farmers in the use of their land. Historic production trends in the sub-areas in recent decades were used in the economic budgeting model for the 1980 projections. A proportion of the current acreage of each crop in a particular sub-area was required to be produced in that sub-area. Feed grain requirements were linked to past trends in livestock production (Appendix Table 2). The efficiency aspect of the economic budgeting principle was used to distribute remaining production to the sub-area in the 1980 projection of land use. For subsequent projection years, the five sub-areas were allowed to compete with each other on a minimum cost efficiency basis. Land use in the study area was based on these efficiency criteria and reflects the ability of Basin farmers to use their soils to compete within the sub-region.

The results of the simulation procedure used in projecting what farmers will do under conditions of average weather and management and economic considerations indicate that there is sufficient cropland to more than meet production objectives in the projection years.

An assumption was made that all permanent pasture would be used to partially fulfill the livestock roughage needs. In evaluating roughage needs that would be met from available cropland, total roughage requirements were reduced by the amount produced from the permanent pasture acreage. To the extent that this assumption is not met, some of the idle cropland acres would be needed to satisfy roughage objectives.

About 17 percent or 411,000 acres of cropland was idle in 1960. Idle acreage increases to a high of 1,294,300 or 54 percent in 1980, due to several factors, the most important of which are the introduction of greater efficiency in production of crops and livestock, large increases in per acre yields and absolute decreases in some of the food and fibre needs from those in 1960. After 1980, the percentage of idle acreage declines continuously in each decade to 2020, when it reaches a low of 404,000 acres, nearly 19 percent of all cropland. The unused cropland is less productive and consists mainly of soil in management groups 4 and 5. In some instances these soils are better suited to the more extensive uses such as forest and woodland or permanent pasture.

Major Commodity Components

All crops considered in this study have been combined into four commodity groupings for report purposes. The food crop grouping consists of the four cash crops: wheat, soybeans, dry field beans and potatoes. Components of the feed crop grouping are corn, oats and barley. Roughages include corn silage, alfalfa mixtures, other hay, cropland pasture and permanent pasture. The final major grouping consists of all minor crops such as fruits, vegetables, small fruit, miscellaneous small grains and sugar beets.

Acreages of all major crops in the Basin, with the exception of feed crops, decrease from 1960 to 1980 and then increase again to 2020. The low acreage for feed crops is reached in 2,000, due to expected production shifts among sub-areas which favor land outside the study area. Food crops and other crops reach their largest acreages in 2020, since projected yields were not sufficient to meet the population's demand for food without adding new acres. The acreage of roughages increases from 1980 to 2000, and then begins a steady downward trend because of the declining use of roughages assumed in feed rations.

Food crop production by 2020 requires the greatest proportion of land available for growing crops, including permanent pasture acreage (Table 14). Roughages generally are the most important in terms of acreage with the exception of idle land for the two decades of 1980 and 1990. Food crops were grown on 16.6 percent of the land available in 1960. This percentage increases to 31.5 by 2020, nearly double the share over the 60-year period. The proportion of feed crops, although increasing over the last 20 years of the period, is 10.7 percent below the 1960 level by 2020.

Additional restrictions, as stated before, were placed on the 1980 run of the simulation model to reflect partially the current production trends. These trends are reflected in the 1970 and 1990 production patterns as well.

Between 1960 and 2020 the percentage of cropland producing minor crops increases about two and a half times. Most of this increase comes from fruits and vegetables which make up an increasing part of this category. Minor small grain acreages were held steady and mint acreages were decreased to zero by 1990, because of the plant disease problems in that particular industry.

A relatively new agricultural enterprise is the raising of sod crops for landscaping purposes. Generally, this crop is grown on organic soils near the larger urban centers and it competes favorably with vegetable production and other intensive uses of this soil.

Total production of the major commodity groupings increases by only 20 percent between 1960 and 2020, but greater adjustments take place among commodity groups (Table 15). Food crop production increases the most over this period rising nearly 928 thousand tons. The increase in feed crops is only about 300 thousand tons. Roughages decrease nearly 617,000 tons over the same period. For livestock production, however, the combination of the last two

Table 14. Distribution of acreage in major commodity groupings, Grand River Basin study area, 1960 and projections by decade to 2020 1/

Item 2/	Time						
	1960	1970	1980	1990	2000	2010	2020
	Percent						
Food crops	16.6	11.5	6.2	13.9	22.1	26.6	31.5
Feed crops	24.3	17.8	11.0	8.9	7.1	10.3	13.6
Roughages	39.4	35.7	31.9	35.7	40.0	33.8	27.1
Minor crops	3.8	3.6	3.3	5.1	7.0	8.0	9.0
Unharvested cropland	1.5	1.1	.6	.9	1.1	1.3	1.4
Idle land	14.4	30.3	47.0	35.5	22.7	20.0	17.4
Total crop and pasture land	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1/ Distributions are based on acreages shown in Appendix Table 3.

2/ Food crops: wheat, soybeans, dry field beans and potatoes
Feed crops: corn, oats and barley
Roughages: corn silage, alfalfa mixtures, other hay, cropland pasture and permanent pasture
Minor crops: fruits, vegetables, small fruits, miscellaneous small grains and sugar beets

Table 15. Production of major commodity groupings in tons of product, Grand River Basin study area, 1960 and projections to 2020

Items	Time						
	1960	1970	1980	1990	2000	2010	2020
	---000 tons---						
Food crops	508.3	403.4	298.6	641.4	987.9	1,215.3	1,436.0
Feed crops	716.9	718.8	720.7	680.5	654.6	838.3	1,016.2
Roughages	1,874.7	1,628.2	1,381.6	1,478.9	1,608.2	1,431.8	1,257.9
Total production	3,100.0	2,750.4	2,400.9	2,800.8	3,250.7	3,485.3	3,710.1

items of feed and roughages is important. Total tonnage in this combination drops by about 318 thousand tons from 1960 to 2020. However, livestock feeding efficiencies discussed in an earlier section allow for important increases in livestock production from a given quantity of feed.

Basin Livestock Production Patterns

The ability of produce feed grains and roughages has a major influence on the location of livestock production. Livestock production patterns in the Basin compared with the sub-region, however, do not change greatly from current proportionate shares. Trends over the 60-year study period are for the Basin to increase its share of all livestock products except beef and veal. Changes in share of turkey, pork and egg production are negligible.

Current production of beef and veal in the Basin is nearly one third of the sub-region's production. Lamb and mutton production in the Basin equals 42 percent. The Basin produced more turkey than the remainder of the sub-region. Shares of milk and egg production both currently exceed one third of the sub-region's production. Pork production is nearly two fifths and chickens are over 44 percent of total sub-regional production of these products.

Total tonnage of all livestock products produced in the Basin increases by 127 percent between 1960 and 2020 (Table 16). Greatest increases in particular commodities come in turkey, beef and veal, pork and milk production. The smallest increase occurs in chicken production. Egg production and the production of lamb and mutton increases by about four fifths over the 60-year period. Decreases in tonnages of certain product groups between 1960 and 1980, reflect trends in declining per capita consumption of these items along with a smaller sub-regional allocation of national production.

Table 16. Production of livestock and livestock products in tons of product, Grand River Basin study area, 1960 and projections by decade to 2020

Livestock item	Time					
	1959-61	Current Basin share of sub-region total	1980	2000	2020	Increase from 1959-61 average to 2020
	000 tons	---Percent---	---------000 tons----------			----Percent----
Beef and veal	60.1	32.3	75.6	105.1	135.0	124.6
Lamb and mutton	3.6	42.0	3.4	4.9	6.6	83.3
Pork	41.4	38.7	50.7	70.9	94.0	127.0
Chicken	8.4	44.3	5.2	7.9	10.6	26.2
Turkey	6.2	67.9	9.5	13.2	17.4	180.6
Milk	731.7	36.6	878.0	1,239.6	1,678.2	129.4
Eggs	18.4	36.9	17.8	25.0	33.5	82.1
Total	869.8		1,040.2	1,466.6	1,975.3	127.1

Fertilizer Use

Total fertilizer use on major crops in the Basin increased by 212 percent between 1959 and 2020. Application rose from nearly 55 thousand tons to over 171 thousand tons of actual nutrients in the form of nitrogen, P_2O_5 and K_2O (Table 17). Increases over 1959 were greatest for potash (K_2O). The decline in potash use between 2000 and 2020 is due to adjustment in the mix of crops grown, primarily roughages which are high potash users. Increase in nitrogen use over the beginning levels of 1959 was 260 percent. Phosphoric oxide (P_2O_5) increased 161 percent over the 60-year period from nearly 23 thousand tons to over 59 thousand tons.

Per acre applications of all plant nutrients generally increase over the study period. The greatest increase on a per acre basis however, occurs in the application of nitrogen. The plant nutrient ratio per acre changes from a 1-2-2 ratio in 1959 to a 2-3-4 ratio by 2020, as the crops grown and soils used for production adjust to meet the production objectives.

Production Costs

The development of production costs was discussed in an earlier section but in general they are made up of costs for growing and harvesting the crop and the cost of materials used in production. In terms of the 1963 constant dollar prices used in the economic budgeting model, total cost of producing the 1980 Basin crop output is 35.1 million dollars. By 2000, the cost rises to $56.6 million and in 2020 is $68.6 million. Per acre cost of production also increases over the same period from $35.89 in 1980 to $38.13 in 2000 and to $47.42 by 2020. These per acre costs are merely averages of the cost of producing all crops. They do not necessarily represent the same mix of crops or relative quantities produced. They are presented here only to give an indication of relative magnitudes.

Table 17. Commercial fertilizer use on major crops, Grand River Basin study area, 1959 estimates and projections to 2020 1/

Year	Total fertilizer applied			Total	Average application per acre 3/		
	N	P_2O_5	K_2O		N	P_2O_5	K_2O
	------000 tons------				-------pounds------		
1959 2/	11.4	22.6	20.9	54.9	12	24	22
1980	18.7	29.4	43.8	91.9	38	60	90
2000	28.3	50.5	80.6	159.4	38	68	109
2020	41.1	59.1	71.3	171.5	57	82	99

1/ Does not include fertilizer applied to permanent pasture or the minor crop category of fruit, vegetables, etc. Certain crops in this latter category have high nutrient requirements.

2/ Commercial Fertilizer Used on Crops and Pasture in the United States - 1959 Estimates, USDA Statistical Bulletin No. 348, p. 18.

3/ Actual plant nutrients.

Likely Production Adjustments

The economic budgeting model as part of its output, indicates marginal costs of production for each crop grown on every soil management group. A determination of the least costly means of adding new production can be made from analysis of these marginal costs. Also, in the event of surplus production, the soils that would not be needed for production can be determined. Marginal costs in this analysis indicate only the immediate shifts likely. They do not indicate the magnitude of potential shifts.

Expanded sub-regional output requirements for 1980 would likely favor Basin soils in the production of wheat, corn and soybeans. If requirements were increased in 2000, efficient allocation of production would favor the Basin in the production of wheat, corn, soybeans, corn silage, other hay and cropland pasture. Areas outside the Basin would satisfy the needs for the remaining crops. For the year 2020 marginal costs of production are quite similar for the most productive soils among the areas in the sub-region. Additional requirements for nearly all crops could partially be satisfied in the Basin. There is, however, a slight advantage for such crops as corn, oats, corn silage and hay crops.

Assumptions and Limitations

In developing the Basin cropping patterns farmers were assumed to be efficiency motivated. To the extent that farmers do not adopt technology at the rate foreseen in this study the trends toward efficient production estimated may be in error.

The economic budgeting model used in projecting production patterns indicates that there will be idle acreage based on efficiency criteria. If farmers are less efficient than was assumed in the simulation model, more acreage will be needed to

meet production objectives. Also, there exists the possibility that estimates of national requirements or sub-regional shares are too low. Additional acreage would be needed in this case also.

Livestock and livestock products were converted into feed grain and roughage requirements for the sub-region. It was assumed that livestock production would be closely associated with the location of feed grain and roughage production. However, an excess production of feed grains and roughages in the sub-region is projected. The method for determining the location of livestock production does not account for the possibility that a particular area may be producing livestock and importing feed grains from other areas and regions.

Projected fertilizer use was reflected in the production cost budgets. Total production costs reflect total nutrient costs in terms of commercial fertilizer. These plant nutrients may also be supplied from other sources such as manure. However, the trend is toward greater concentration of livestock production in specialized units and heavier applications of commercial fertilizer for the essential plant nutrients in crop production. The simplifying assumption of all plant nutrients supplied from fertilizer may thus overstate costs slightly. Fertilizer use on permanent pasture and the minor crops was not included in the total fertilizer estimate. This use is not expected to be large.

RURAL FARM POPULATION AND EMPLOYMENT

Projected changes in production levels, increased size and specialization of commercial farms and the adoption of new labor-saving technologies all have important impacts on the rural-farm population and labor force of the future.

Basin Farm Population

Rural-farm families represent a significant share of the total Basin population. Farmers are dependent upon the study area's economy as well as being contributors to it.

Definition and Concepts

Ideally a definition of rural-farm population should account for all of those people who will be responsible for contributing to agricultural production in the Basin. The 1960 Census of Population closely approximates this ideal and that definition is used in this study. Rural-farm population is defined as all rural persons living on farms of 10 or more acres selling at least $50 of products or on farms of less than 10 acres with sales of $250 or more. However, the definition does not include two groups of people who contribute to agricultural production. They are: (1) the people living on farms within the boundaries of towns and villages over 2,500 population; and (2) people who live in both urban and rural areas not on farms but who work on farms and actually derive their major source of support from farming. These two exceptions are minor and do not affect the estimate of rural-farm population significantly. Their effect is to exclude a small portion of the agricultural labor force.

On the other hand there are people classified as farmers by the Census of Population who work part time or full time off the farm. Currently the part-time farmer segment comprises a significant proportion of the rural farm population. Off-farm work is likely to decrease somewhat as larger, more specialized farms provide opportunity for full-time work. Part-time farming may continue to be prevalent in the future. In this case, the projected rural-farm population might be underestimated.

Procedure for Estimating

Projections of the rural-farm population were based on expected numbers of farms and the average size of farms. In order to estimate farm numbers, trends in the average size of farm were analyzed and projected to 2020 by decade. For comparison purposes, trends in numbers of farms in the various size classes were independently projected for the same years. The two projection methods produced similar results in terms of average farm size.

Farms in the Basin averaged 132 acres in 1959 and are projected to average more than 200 acres per farm by 2020 (Table 18). The average farm size in the Basin is much smaller than in most other states due to the large number of small holdings which for definitional reasons are classified as farms but produce only limited amounts of product. For instance, the 1959 Census of Agriculture indicates that average farm size in Illinois and Indiana was 196 acres and 145 acres respectively.

The acreage per farm was divided into the total acreage of cropland, pasture and woodland available to produce the number of farms in each decade. Past trends in farm numbers indicate a steady decline as the average farm size has grown larger. The projected number of farms by decade is consistent with these past trends in fewer but larger farms.

Table 18. Rural-farm population, all farm land, numbers of farms and average farm family size, Grand River Basin study area, 1960 and projections to 2020

Year	Total Basin farm land 1/	Numbers of farms	Average farm family size	Rural-farm population
	-000 acres-	--000--		000 people
1960	3,333.2	25.3	4.19	105.9
1970	3,328.0	22.6	3.87	87.3
1980	3,154.1	19.8	3.80	75.3
1990	2,965.3	17.1	3.70	63.4
2000	2,771.0	14.8	3.60	53.4
2010	2,582.0	12.8	3.60	46.1
2020	2,397.5	11.1	3.60	39.9

1/ Includes cropland, pasture, forest and others

Farm numbers were multiplied by the estimated number of people per farm household to produce estimates of rural-farm population for each decade. Estimates of numbers per household were developed by comparing trends in rural and urban areas. These trends were found to be slowly converging. They were continued in this direction on the basis of consultations with demographers.[16/] Current downward trends in urban household size are expected to continue. The size of rural-farm households is also expected to decline and approach the size of urban households as communication, mobility, standards of living and education levels in rural areas increase.

Change from 1960

Rural-farm population was projected to decrease by over 62 percent between 1960 and 2020 (Table 18). The greater rates of decrease are expected to come in earlier decades since both farm numbers and average size of farm family are decreasing. Rates of decrease after 2000, when average family size is assumed to stabilize, become about 13.5 percent per decade compared to rates of 15.8 to 17.6 percent for earlier periods.

Basin farm numbers are expected to decrease by slightly more than 56 percent over the 60-year period. The decreases are expected to be in the medium size ranges as these farms are consolidated into larger more efficient units. Farms in the larger size classes of 180 acres and larger are expected to increase in number.

16/ J. Allan Beegle, Professor of Sociology and Anthropology and J. F. Thaden, Professor Emeritus, Institute of Community Development and Services, Michigan State University.

Basin Farm Employment

Trends in farm employment as a percent of total employment in the Basin have generally been downward over the past two decades. Two factors are responsible for this trend. Size of the total labor force is increasing while the absolute size of farm labor numbers is decreasing. These trends are projected to continue.

Definition and Concepts

The definitions of farm employment differ between the Census of Agriculture and the Census of Population. In the Census of Population, employment is determined at place of residence and persons are counted as working in the industry from which they earn the greatest income. The Census of Agriculture, however, is taken at place of employment and a particular worker may be counted more than once if he happened to work on more than one farm or in another industry during the week preceding enumeration. The definition of rural-farm employment used in this report conforms closely with that used by the Census of Population but accounts also for seasonal labor which is not reflected in that series.

Procedure for Estimating

Rural-farm labor requirements per acre were developed from trends in total family and hired labor shown in the Census of Agriculture and survey data for operator, family and hired labor by size and type of farm.[17/] Labor requirements per acre were developed for farming operations that were expected to prevail in the future. These requirements reflect off-farm work and were

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17/ "Farming Adjustments in Lower Michigan," unpublished materials from a study made by the Farm Production Economics Division, Economic Research Service, USDA (1963).

developed for various sizes and types of farms. The result is a pure farm labor requirement which includes all labor necessary to meet production objectives regardless of the source of labor.

Total labor requirements were computed on an hourly basis for hired and total labor and converted to man years using the assumed hours worked per year in the Ad Hoc Water Resources Council Staff report. [18/] An average work year was assumed to be 292 days for purposes of this study. This assumption allowed the average number of hours worked per day to decrease over the study period in accordance with the assumed decline in hours worked per year.

Change from 1960

Projected total labor requirements decrease by about 31 percent from 1960 to 2020 (Table 19). Over the same period the hired labor component also decreases reflecting increased use of mechanization in growing, harvesting and other specialization techniques.

The average work year for farm labor declines by nearly 33.5 percent from 1960 to 2020. Agricultural workers were assumed to have a work year equal to the private nonfarm sector of the economy by about 1990. However, the private nonfarm sector work year average only 1998 hours in 1960, some 256 hours less than the agricultural work year.

Assumptions and Limitations

In addition to the assumptions and limitations discussed under the main sections on population and employment there are other limitations which could affect these estimates. Both the estimates of rural-farm population and employment depend directly upon the

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[18/] Op. cit., National Economic Growth Projection 1980, 2000, 2020, July 1963, Appendix Table 3.

Table 19. Rural-farm employment and average work year, Grand River Basin study area, 1960 and projections to 2020

Year	Hours worked per year 1/	Rural-farm labor requirements		Total agricultural workers 2/
		Hired	Total	
	--hours---	---------hundred man years----------		
1960	2,254		191.2	203.0
1970	2,056	16.3	184.2	196.0
1980	1,880	15.9	159.1	171.0
1990	1,758	15.6	152.2	164.0
2000	1,635	12.3	149.0	161.0
2010	1,560	11.1	139.4	151.0
2020	1,500	10.5	132.5	145.0

1/ National Economic Growth Projections 1980, 2000, 2020, July 1963, Appendix Table 3; with interpolations for intervening decades.

2/ The difference of approximately 1200 between total agricultural workers and rural-farm labor requirements represents professional and service employment oriented to the agricultural sector.

assumed changes in average farm size. A large proportion of the total farms projected fall in size classes of less than 100 acres. If the number of small farms decreases by a greater proportion than the projected number, both average size and total numbers would be affected. Adjustments of this type would result in fewer and larger farms which would cause both the estimates of population and labor force to be overstated.

Differences in the assumed size of farm family could also affect the farm population numbers. Potential changes are not expected to be significant especially if family size changes were in the distant future when farm numbers are expected to be smaller.

Limitations in the estimates of labor requirements could occur through variations from the assumed labor productivities per acre. Increasing labor efficiencies at a rate faster than assumed would have the effect of mis-stating the labor force. The projected labor efficiency increases are believed to be conservative, so it is more probably that potential errors would be in underestimating improvement in labor productivity.

Currently some migratory labor is used in producing fruit, vegetables and certain field crops. These laborers are not accounted for in the Census of Population definition. As labor-saving innovations in new machinery are adopted, the quantity of labor from this source will become less significant.

The actual number of workers may be larger than is indicated by the employment figures developed in this chapter. Farm workers who earn part of their income in other employment are counted only for their labor involved producing agricultural products. Those who work the equivalent of the average work year off the farm are not counted in the farm labor force. The significance of this under-counting may decrease as was discussed in the section on rural-farm population.

CONCLUSIONS

Implications for Water Resource Development

Water resource development may be desirable from the standpoint of greater efficiency in agricultural production. Study of the irrigation drainage and the flood protection potential of the Basin will be necessary to determine if water development for agricultural production is needed. Sufficient crop land is expected to be available even in later projection years but farmers may be able to reduce costs through drainage or irrigation. For instance, drainage of certain soils which are currently undrained or partially drained may result in an increase in productivity which would more than pay for the annual cost of the drainage investment.

The product requirements might be produced through improved farm management techniques at a lower cost. Greater applications of fertilizer than were assumed could increase the product from the Basin at lower costs of production.

Production might be expanded for the same cost or the same product produced for less money from any of the alternatives discussed. Throughout, the assumption has been that no cost is associated with idling farmland. Should resource development measures cause resources within the Basin or other regions not to be used, the cost for relocating these resources should be considered. Any of the alternatives have costs associated with them and the results from each should be compared if the resources available to society are to be used in a manner complementary to economic development and growth in welfare.

Implications for the Economy of Rural Communities

Rural communities of the future will be providing services to a smaller farm population and for some, an increased nonfarm population. The services will, however, become much more specialized and involve the latest technologies. Undoubtedly, service facilities will need to expand to handle increased volumes of business. For instance, the local county elevator may not be able to meet future needs of commercial agriculture. New food processing plants will be needed in certain localities. Expanded facilities will require new investment. County seats with good rail and highway transportation networks, larger marketing facilities and greater variety of goods and services for the whole farm family may become the future rural centers. Even these cities may be bypassed if they are within the trade territories of Lansing, Grand Rapids and Jackson.

Appendix Table 1. Production of major crops, livestock and livestock products as a percentage of U. S. production, "Ohio River Basin States," 1939-62 and projected 1980

Year	Feed Grain	Corn, Grain	Rye, All	Oats	Barley
1939	16.2	20.1	10.4	10.6	3.0
1940	13.8	16.0	11.3	12.6	3.2
1941	15.1	18.0	9.8	13.0	3.3
1942	15.3	18.4	9.6	12.6	3.4
1943	13.6	17.6	11.2	7.6	2.2
1944	12.7	15.0	12.7	9.6	2.6
1945	15.4	19.5	11.1	11.0	2.8
1946	14.9	17.4	11.3	12.7	2.4
1947	14.2	19.6	11.3	7.9	2.0
1948	14.8	18.3	11.3	11.1	2.2
1949	16.1	19.0	12.4	11.9	2.6
1950	14.3	17.8	11.4	11.9	2.3
1951	18.8	20.1	9.0	11.6	2.3
1952	15.1	17.7	12.1	11.3	2.1
1953	16.2	19.3	14.0	11.4	2.5
1954	17.2	22.5	18.9	11.0	3.1
1955	17.5	22.1	11.3	12.6	3.3
1956	17.5	21.2	13.8	12.2	3.4
1957	14.1	17.9	9.5	9.1	2.5
1958	14.7	17.9	9.7	11.3	2.4
1959	15.9	18.6	12.5	11.7	2.0
1960	16.4	19.0	8.5	13.1	2.1
1961	15.4	18.2	10.7	10.3	2.3
1962	16.4	19.5	7.1	11.6	1.7
1980	18.0	20.0	8.0	12.0	2.0

Appendix Table 1 cont.--

Appendix Table 1 (cont.). Production of major crops, livestock and livestock products as a percentage of U. S. production, "Ohio River Basin States," 1939-62 and projected 1980

Year	Soybeans	Wheat, All	Dry Beans	Potatoes	Vegetables	Fruit, Non-citrus
1939	--	11.4	--	--	12.3	--
1940	25.7	11.6	25.5	9.5	11.6	6.8
1941	27.2	11.2	28.0	11.1	13.6	7.9
1942	28.4	7.1	27.4	10.0	13.1	7.6
1943	28.5	6.6	26.1	8.8	9.4	5.0
1944	26.0	9.4	28.6	8.3	9.8	7.3
1945	26.4	11.3	22.2	7.7	9.9	3.9
1946	22.2	9.1	25.0	7.0	10.6	5.9
1947	26.0	8.9	18.0	6.0	8.7	7.0
1948	23.8	10.6	21.9	6.2	11.6	5.6
1949	25.2	12.3	27.7	6.9	7.9	9.0
1950	22.1	11.0	21.9	6.9	8.1	8.3
1951	22.8	9.4	25.4	6.9	8.8	6.8
1952	21.3	10.2	23.3	5.9	8.6	6.8
1953	23.2	14.0	22.7	5.8	8.7	8.2
1954	23.3	12.4	19.4	6.3	8.7	6.7
1955	20.9	11.7	27.2	5.0	7.8	6.2
1956	20.0	11.1	31.3	5.3	7.7	8.0
1957	19.4	10.1	22.4	4.7	7.5	7.9
1958	18.7	8.9	27.1	5.0	7.5	8.4
1959	20.0	9.2	33.9	5.2	8.6	8.4
1960	20.0	9.5	34.9	4.9	8.9	8.7
1961	20.0	10.9	36.2	4.7	9.0	8.7
1962	20.1	10.2	40.0	5.2	10.2	8.1
1980	18.0	8.0	42.0	4.0	9.0	9.5

Appendix Table 1 cont.--

Appendix Table 1 (cont.). Production of major crops, livestock and livestock products as a percentage of U. S. production, "Ohio River Basin States," 1939-62 and projected 1980

Year	Cattle and Calves	Sheep	Hogs Lbs.	Milk	Chickens, All	Eggs	Turkeys
1939	10.2	--	17.3	13.4	--	14.8	--
1940	10.0	11.1	18.5	13.3	14.0	14.6	6.2
1941	9.5	10.4	17.9	13.4	13.3	14.6	5.7
1942	9.2	10.2	17.3	13.6	12.8	14.0	6.0
1943	9.2	10.4	16.0	13.5	12.7	13.3	6.1
1944	9.2	9.8	17.5	13.6	12.4	13.2	6.6
1945	8.9	10.1	16.8	14.1	12.3	13.3	7.2
1946	9.0	10.5	17.7	14.1	12.6	13.5	7.6
1947	8.7	9.8	16.9	14.2	12.4	13.6	8.5
1948	9.0	10.8	17.2	14.3	12.0	13.9	8.5
1949	8.7	10.9	17.4	14.5	11.6	13.8	8.0
1950	8.7	9.9	17.3	14.4	10.9	13.2	8.4
1951	8.4	9.7	16.5	14.3	10.1	13.0	8.2
1952	8.4	10.1	16.6	14.5	10.1	13.0	8.4
1953	8.5	11.0	17.2	14.4	9.9	12.6	9.6
1954	8.3	10.2	16.8	14.3	9.6	12.7	10.1
1955	8.0	10.3	16.5	14.2	8.8	12.4	9.3
1956	8.3	10.5	17.3	13.8	8.2	12.6	8.9
1957	8.5	9.8	17.3	13.6	7.3	12.2	9.1
1958	7.7	9.8	16.1	13.2	7.1	12.0	10.4
1959	7.6	8.8	16.3	13.1	6.0	12.0	9.6
1960	7.8	8.3	17.3	13.0	5.1	11.9	9.4
1961	7.6	8.1	17.2	13.3	4.9	11.3	9.4
1962	7.7	7.9	17.5	13.4	4.0	11.0	9.8
1980	6.5	7.5	17.5	13.0	2.0	10.0	10.0

Source of basic data: Statistical Reporting Service, U.S.D.A.

Appendix Table 2. Grand River Basin study area trends in production by commodity as a percentage of state production

Year	Dairy	Corn	Wheat	Oats	Potatoes	Dry Beans	Sugar-beets
	-No.-	--------Bu.--------			--------Cwt.--------		-Tons-
1947	21.6	26.5	30.4	31.2	19.7	17.3	14.2
1948	22.7	26.8	30.4	25.7	16.6	16.2	13.3
1949	23.0	29.3	27.3	26.1	32.7	19.7	15.8
1950	23.0	27.8	27.4	26.9	19.0	21.2	13.8
1951	23.2	29.1	29.4	27.4	21.8	16.2	9.7
1952	23.2	30.4	27.7	28.2	22.1	18.0	11.6
1953	22.5	28.4	27.4	26.9	20.2	18.4	10.2
1954	23.2	27.8	26.8	27.9	21.0	21.9	13.7
1955	23.9	27.1	29.1	26.8	22.1	18.0	7.8
1956	23.7	28.8	26.7	22.9	19.0	17.9	6.9
1957	24.2	26.6	26.4	24.5	20.5	14.6	5.8
1958	24.5	25.3	29.0	25.7	22.7	19.0	4.1
1959	24.5	27.9	30.0	25.0	27.8	25.7	3.6
1960	24.7	30.6	28.2	24.6	22.7	25.5	2.2
1961	25.1	26.3	37.9	23.0	21.5	23.8	2.3
1962	25.1	25.1	22.4	22.5	21.3	23.4	2.6
1963	25.1	27.7	28.1	23.0	22.7	26.2	3.3

Appendix Table 2 cont.--

Appendix Table 2 (cont.). Grand River Basin study area trends in production by commodity as a percentage of state production

Year	Barley	Soybeans	All Hay	Sheep	Poultry	Hogs	Beef
	-------Bu.-------		--Tons-	----------No.----------			
1947	12.1	9.3	19.7	34.1	23.6	24.4	23.3
1948	9.3	10.2	21.0	33.3	23.8	25.6	17.6
1949	8.5	9.2	20.5	33.1	23.8	27.4	23.1
1950	10.0	13.9	21.2	33.4	24.0	28.2	21.3
1951	8.6	19.7	20.5	33.2	23.4	29.1	24.3
1952	9.8	16.9	21.8	32.6	23.1	29.2	25.9
1953	12.3	17.0	19.7	30.3	24.3	29.0	24.7
1954	19.8	15.3	21.0	30.5	25.3	29.6	23.3
1955	20.2	14.5	20.9	30.1	24.4	30.2	22.0
1956	21.8	19.2	21.4	30.8	26.0	29.6	23.1
1957	22.7	19.4	21.5	32.3	26.0	29.5	23.4
1958	26.9	20.3	24.0	30.0	25.7	30.0	23.9
1959	36.0	17.4	23.2	32.4	27.3	27.4	24.1
1960	29.0	21.4	21.8	33.2	25.8	31.5	24.4
1961	31.6	24.2	22.8	--	--	32.0	23.7
1962	31.3	20.6	23.0	--	--	32.1	23.1
1963	26.0	23.4	23.2	--	--	31.1	22.9

Appendix Table 3. Acreage of major crop and pasture uses, Grand River Basin study area, 1960 and projections by decade to 2020

(In Thousands)

Item	Time						
	1960	1970	1980	1990	2000	2010	2020
Food crops	474.2	321.4	168.5	365.1	564.9	648.1	727.6
Feed crops	691.0	494.5	298.1	234.9	182.3	251.1	316.6
Roughages	1,123.9	995.8	867.7	942.8	1,019.5	824.3	629.8
Other crops	107.4	99.1	90.8	134.5	178.2	193.9	209.6
Total cropland use	2,396.5	1,910.8	1,425.1	1,677.4	1,944.8	1,917.4	1,883.6
Idle cropland	452.9	873.6	1,294.3	958.4	607.3	519.2	437.4
Permanent pasture use	2,017.5	1,549.3	1,081.1	1,357.9	1,649.9	1,656.2	1,656.2

Source: 1960 base acreages developed from the National Inventory of Conservation Needs and the 1959 Census of Agriculture.

LOCATIONS OF COPIES OF APPENDIX O

	County	Municipality	Institution
Basin Public Libraries:			
1.	Barry	Hastings	William T. Wallace Memorial Library
2.	Clinton	Saint Johns	Bement Public Library
3.	Eaton	Charlotte	Charlotte Free Public Library
4.	Gratiot	Alma	Alma Public Library
5.	Ingham	Lansing	Michigan State Library
6.	Ionia	Ionia	Hall Fowler Memorial Library
7.	Jackson	Jackson	Jackson Public Library
8.	Kent	Grand Rapids	Grand Rapids Public Library
9.	Montcalm	Greenville	Greenville Public Library
10.	Ottawa	Holland	Herrick Public Library
11.	Shiawassee	Owosso	Owosso Public Library
University Libraries:			
1.	Ingham	East Lansing	Michigan State University Library
2.	Ottawa	Allendale	Grand Valley State College Library
3.	Washtenaw	Ann Arbor	University of Michigan Library
4.	Wayne	Detroit	Wayne State University Library
Other Libraries:			
1.	Ingham	Lansing	Michigan State Historical Commission
2.	Wayne	Detroit	Detroit Public Library

County Agencies:

Copies of the report have also been distributed to all County Clerks, Drain Commissioners, and Planning Commissions in the Basin (counties listed above, under "Basin Public Libraries").