UNITED STATES DEPARTMENT OF AGRICULTURE
Economic Research Service

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WATER RESOURCES AS A LIMITING FACTOR IN ECONOMIC GROWTH

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INTRODUCTION

The objective of our national policy for planning and development of water and related land resources is to provide the best use, or combination of uses, to meet all foreseeable short- and long-term needs. The policy as stated by the ad hoc Water Resources Council and approved by the President states that full consideration shall be given to each of the following objectives and reasoned choices made between them when they conflict (17):

A. National economic growth and economic development of each region.
B. Preservation of open space, green space, and wild areas of rivers, lakes, beaches, mountains, and related land areas for recreation; and areas of unique natural beauty, or historical or scientific interest.
C. Well-being of all of the people.

My assignment deals with water resources as a limiting factor in economic growth; thus, I will not be concerned with preservation or well-being as objectives independent of economic growth. Where conflicts arise, I recognize that the intangible values from preservation of resources or increasing the well-being of people often may be more important than national economic growth.

One measure of economic growth is the increase in the total Gross National Product. GNP represents the market value of total national output of goods and services. It is an estimate of the total product of the factors of production, land, labor, capital, and entrepreneurship. Output of these goods and services valued at constant dollar prices provides a measure of the gross product of the economy. If the GNP increases faster than population, there will be an increase in the product per capita and a rising level of living per person (3). Growth may occur in some sectors of the economy and not in others or in some regions and not in others. Some regions or groups may be largely passed over and benefit little, if any, from an increase in the national product; they actually may be disadvantaged. The drives influencing economic growth spring from demand. Consumer demand is the big, steadily expanding sector. Shifts in Government demand resulting from war, defense preparation, and domestic development programs have been an important source of demand in the past two decades. Combined, these demands largely determine business investment demand.

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*Presented at the American Society of Civil Engineers Environmental Engineering Conference, Salt Lake City, Utah, May 11-15, 1964.

While the water resource should be considered as it occurs in the entire hydrological system, I have limited my discussion to the water supply represented by precipitation. In economic terms, water is a flow resource subject to storage and management (except for closed ground water basins). It has quantity, quality, energy, time, and location aspects. Since it is a flow resource, it must be used as available (except to the extent it can be stored). Water is essential to all of man's activities, but in most situations it is not transferred in the market independent of land resources. Property rights govern the use and control of the resource.

The legal and organizational arrangements dealing with water reflect the variation in availability of the resource and differ greatly from the humid States to those with arid climates.

The consideration of any one use of water must be treated as an integral part of an analysis of water requirements for all uses by all sectors of the economy. The shorter the supply of water, the more essential the need for taking account of all competing uses. Consideration of the water needs for any particular purpose is but an initial step in approaching the problem of comprehensive multipurpose development.

The problem for this paper might be stated in these terms: Can we foresee a time when water shortages now evident in some areas will become more widespread, thus creating a national water problem? when using water for one purpose means giving up some other purpose? for example, when increasing irrigation might mean limiting industrial use? when increasing industrial use might mean limiting fish production or recreation? Will we reach a point where the availability of the water resource affects not only economic productivity but also limits economic activity in an area and thus restricts employment?

I will attempt to explore these questions in terms of economic growth at the national level and to explore how variations in the occurrence of water resources influence regional economic development as distinguished from national economic growth. I will use regional economic development to indicate the portion of national output contributed by the region. Factors that would increase the productivity of a region could result in increased national growth. Factors that would attract a greater proportion of economic activity and employment to a region without an increase in productivity might increase that region's output at the expense of some other region but have no direct effect on national growth. Development of resources for less-productive uses could retard national economic growth compared with more productive development.

PRODUCTION FACTORS

The production factors influencing the national output of goods and services are illustrated in chart 1. This is a greatly simplified explanation which assumes that in the long run natural resources and technology are important determinants of productivity and potential regional and national output (15). The chart provides a framework in which we can indicate the relation of water resources to economic growth.

PRODUCTION FACTORS DETERMINING GROSS NATIONAL PRODUCT

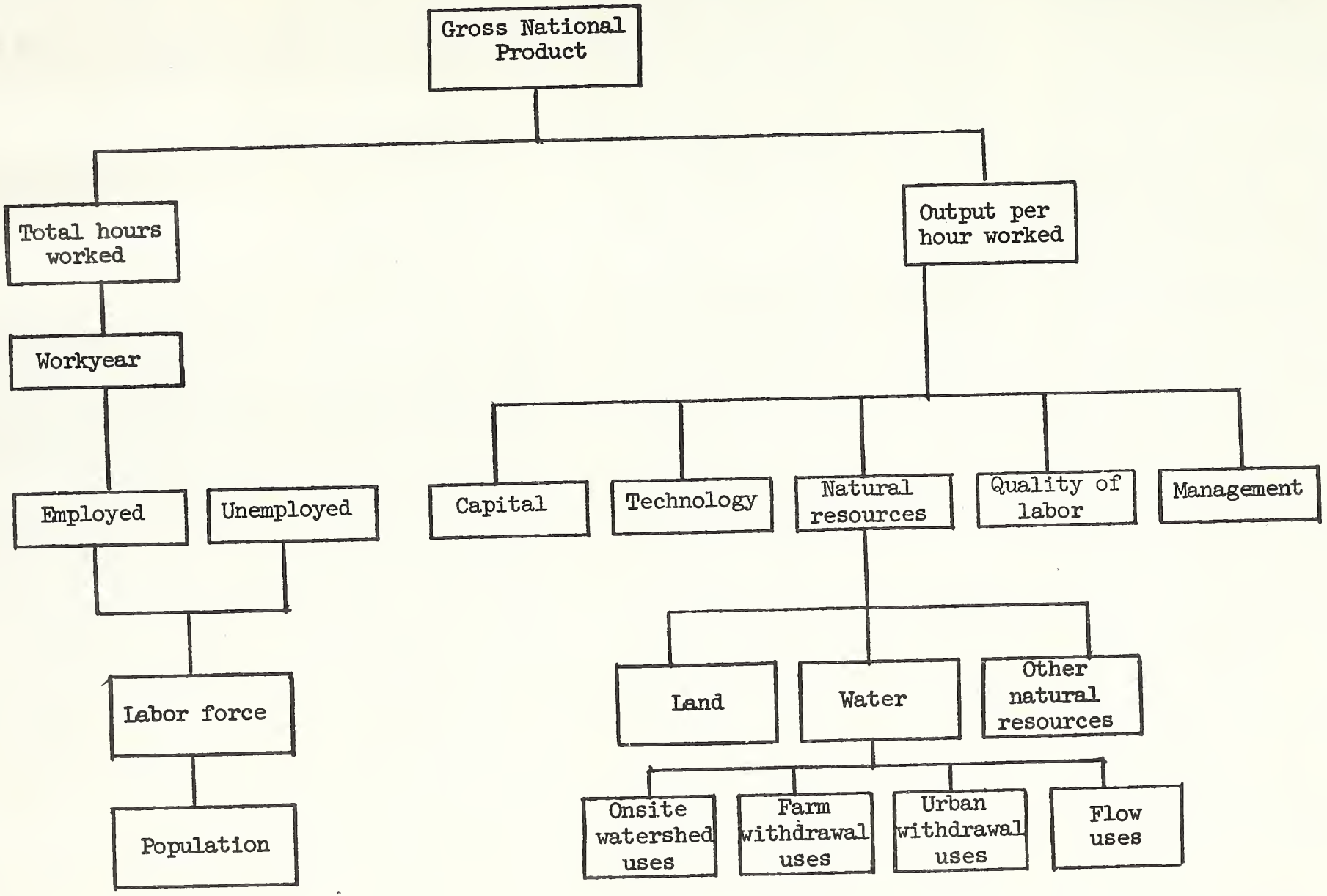

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Chart 1

First, taking the left side of the chart, we find that the hours worked are determined by the workweek, the workyear, and the number of people employed. The unemployed are not contributing to the GNP, and there are all shades between fully employed and unemployed. Underemployment or misallocation of labor may affect both hours worked and output per hour. The labor force is determined by size of the population and the proportion participating. As can be seen from this chart, there are many factors that could change the total hours of labor available and thus the potential output. During World War II, the number of hours worked was increased by an increased participation in the labor force and a longer workweek and workyear. Since the war, the workweek and the workyear both have been gradually reduced.

On the right side of the chart we find a number of factors affecting productivity as measured by the output per hour worked. The quality of the labor in terms of education, skills, and motivation are important, as are the supply of capital and the level of technology, knowledge, and management.

Perhaps most important of all in the long run and most pertinent for the purposes of this paper are the quantity and quality of natural resources available to the economy and the natural environment in which people live. While the level of technology and available capital greatly affect the productivity of natural resources, there are limited substitutes for natural resources which respond favorably to these manmade forces. There is a vast array of natural resources, but of interest here is the water resource. In the chart the uses of our water resources have been divided into onsite watershed, farm withdrawal, urban withdrawal, and flow uses.

USE OF THE NATION'S WATER SUPPLY

The first impact of our annual water supply of 4.75 billion acre-feet of precipitation is on the surface of the land. The nature of vegetative cover, land slope, soil characteristics, cropping patterns, and conservation practices are major factors influencing the extent to which precipitation becomes soil moisture for evapotranspiration, deep percolation, or surface runoff. About 3,380 million acre-feet, or 70 percent, of the total water supply is used by evapotranspiration from watershed lands (1, 7).

Chart 2 shows these onsite watershed uses.

About 1,100 million acre-feet, or 33 percent, of the water used on watershed lands is used for the production of farm crops and pastures. These nonirrigated lands currently account for about 80 percent of the value of the Nation's crop and pasture production, and thus about four-fifths, or $29 billion, of the cash receipts from farming (8). This component contributed an estimated $17 billion to GNP. Associated with and influenced by the location of this primary farm activity were agriculturally related industries, with an estimated contribution to the GNP of $100 billion. These crop and pasture lands are in private ownership

and operation, and research and technology have brought about large increases in productivity. It is expected that these nonirrigated lands will continue to be the major source of farm production.

Another 750 million acre-feet, or 22 percent, of the onsite watershed use is used in the production of timber and browse. These lands account for the Nation's timber production valued currently at $2.6 billion. The GNP arising from the timber-based economic activities has been estimated at $25 billion (4). Forest lands also have value for many other purposes, including recreation and water yield. A substantial portion of the forest land is in public ownership and is managed for multipurposes.

About 1,530 million acre-feet, or 45 percent, of onsite watershed use is on lands supporting vegetation with little, if any, market value (7). Many of these lands have important scenic, recreation, fish and wildlife, or other values. It is not possible to estimate any general relationship between the use of water on these lands and economic activity. The Senate Select Committee studies projected larger water requirements for wetlands for future wildlife habitat. The benefits from the use of these lands are diffused to the public, and a large proportion of the lands is in public ownership.

Water-caused erosion is a major problem on a large proportion of our cropland, pasture, and woodlands. Losses from erosion damage to these watershed lands and resulting damages from sedimentation are estimated to approach $1 billion annually (16).

The manner in which farm, range, forest, and other watershed lands are managed has a direct impact on the potential yield and quality of water. Our ability to manipulate water yield is limited now, but at some future time research may improve our ability to manage watershed land use so as to reduce uneconomic uses of water, to increase the efficiency of onsite water use, and to improve the quantity, quality, and timing of water yield available for downstream economic uses. Since such a large proportion of our total water supply (70 percent) is used on watershed lands, gains in efficiency of water use, water yield, or water quality would be of great significance.

Chart 3 shows how the 30 percent of our precipitation that constitutes our streamflow of 1,370 million acre-feet is used (7). Examination of data from a number of sources indicates that about 267 million acre-feet, or 20 percent, of streamflow is withdrawn for farm and nonfarm uses. Another 20 million acre-feet is mined from ground water, making a total withdrawal use of 287 million acre-feet (1, 5, 7, 13).

Farm withdrawal amounts to 107 million acre-feet, of which 60 percent is lost through evapotranspiration and 40 percent returns to streamflow. About 103 million acre-feet is used for irrigation which produces about 20 percent of the value of crop and pasture production and estimated cash receipts of $7 billion. Irrigated farming contributes an estimated $4 billion to the GNP. Agriculturally related industries whose location is influenced to some extent by the location of irrigation contribute an

WATER USE ON WATERSHED LANDS

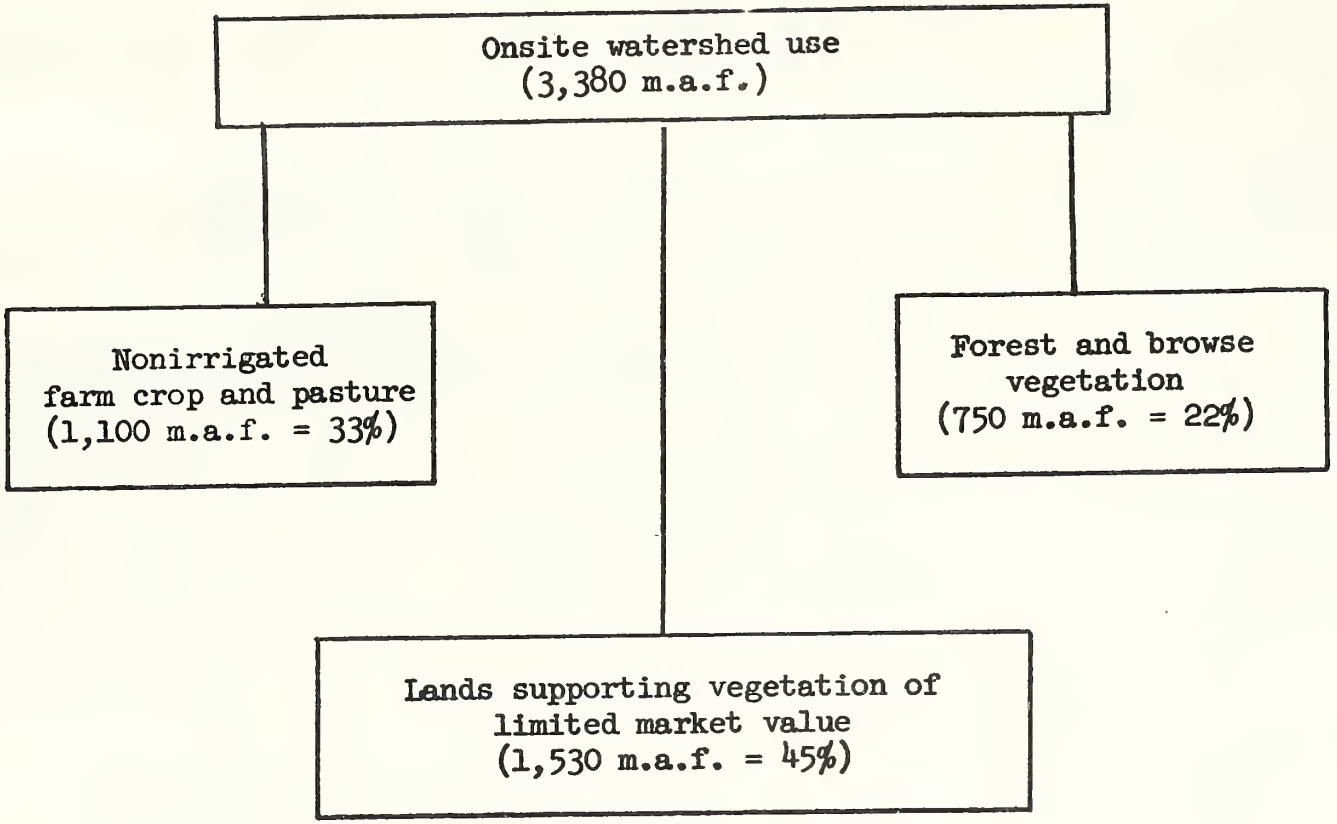

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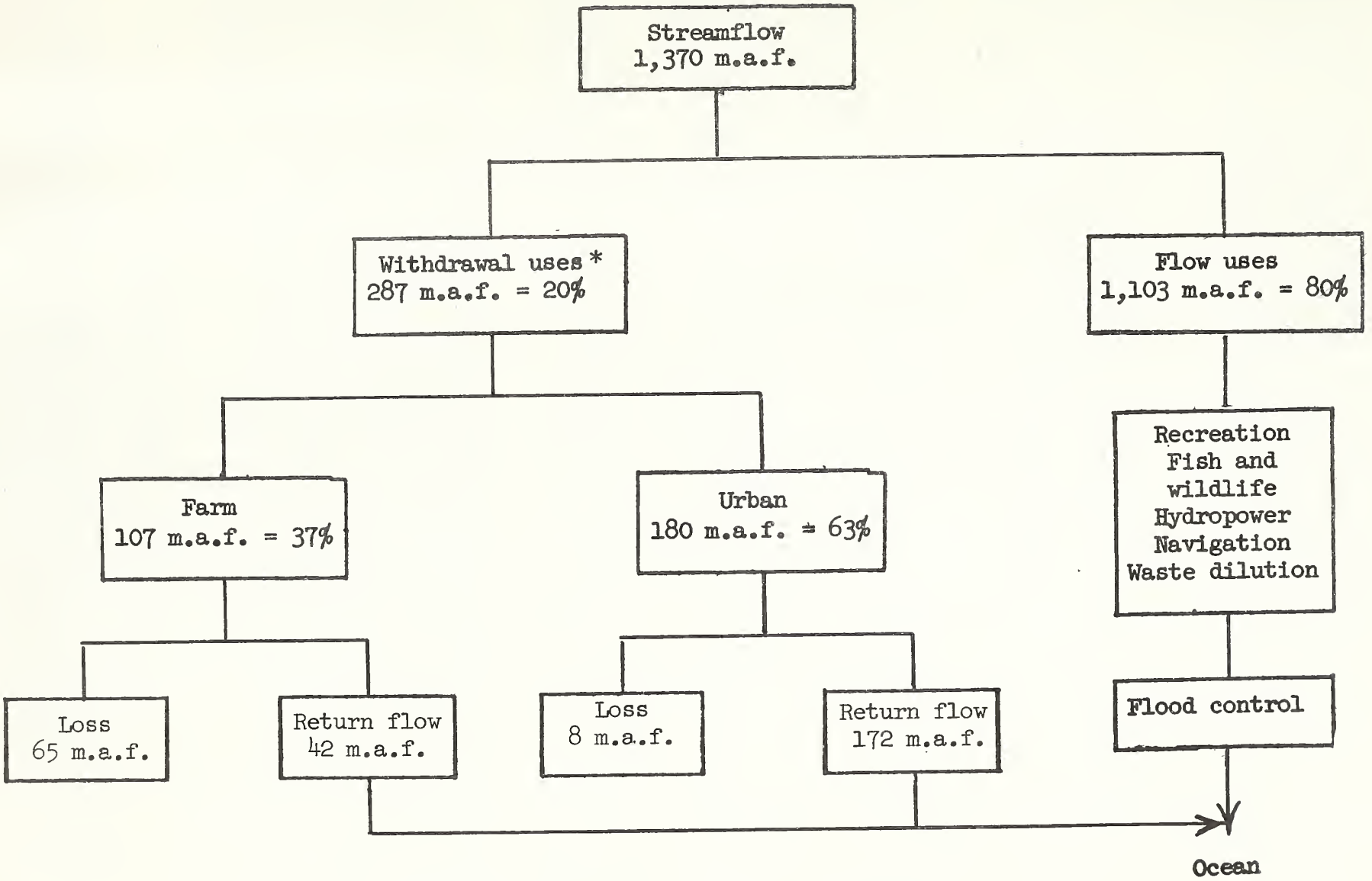
Chart 2

CONCENTRATED WATER SUPPLY



*Includes 20 m.a.f. mined ground water.

estimated $25 billion to the GNP. There is considerable evidence that great improvement is possible in the efficiency of water use in irrigation (8). Lack of economic incentives, legal obstacles, and lack of technical information, however, have hampered adoption of improved practices. Because of the high consumptive use of water for farm irrigation, livestock, and household purposes, farm use accounts for 88 percent of total consumptive use of water withdrawn from the concentrated supply.

Withdrawals for urban uses, including industrial, municipal, and other uses, account for 180 million acre-feet, or 63 percent, of total withdrawal uses. Some industries are much heavier users of water than others. On the average, however, only 5 percent is lost, so 95 percent is estimated to return to the river systems although the quality may be impaired.

The Senate Select Committee studies show that waste dilution and quality control will become the largest water requirement (13). These studies indicate that the streamflow necessary for waste dilution with a high level of waste treatment also would provide water for urban withdrawal uses.

If the flow uses such as recreation, fish and wildlife habitat, navigation, and waste dilution are combined with urban withdrawal uses, a large proportion of the Nation's economic activity and a very large component of the GNP would be associated with such uses of our rivers and streams.

Flood flows cause a loss in economic activity. Flood damages are estimated at about $1 billion annually, of which $425 million is upstream and $575 million downstream. Damage to farm property is almost one-half the total (16).

These rough estimates of the association of water use and economic activity pose some questions about our water management policies which can be answered only by an expanded program of basic research and comprehensive planning. Providing a water storage and management system for a river basin to meet the present and future needs of our economy for withdrawal and flow uses and to minimize flood damages is a public responsibility involving all levels of government. Of equal importance to our economy is the quality of the water input into the system as it comes from runoff from watershed lands and return flow from agricultural and urban uses.

REGIONAL ECONOMIC DEVELOPMENT

The total annual average water supply of 4.75 billion acre-feet is not distributed uniformly over the country and the requirements for water are not distributed in relation to the available resources. So the water problem varies according to many local and regional factors.

Chart 4 shows the annual precipitation in acre-feet per square mile in each water resource region; the national average is about 1,600 acre-feet per square mile. As will be seen from this chart, evapotranspiration tends to be high in regions where the precipitation is low. Consequently, runoff in these regions is relatively low when measured on a unit area basis (9).

This regional variation in availability of water resources is reflected in economic activity in the various regions. The most critical deficiencies in regional water resources are already reflected in the extent of primary economic activity in these regions.

For example, seven Western regions (excluding the Pacific Northwest and Central Pacific), with almost half of the total land area of the conterminous United States, contribute only 23 percent of the value of nonirrigated crop production. These regions have pushed irrigation development and produce 50 percent of the value of irrigated crop production (8).

If we examine employment in principal water-using industries, we find that the seven Western regions have about 10 percent of the U. S. total (12). These seven regions have about 17 percent of the total population (10).

Although many factors are involved, there is little doubt that availability of water resources has been a major influence on the type of economic development occurring in these regions.

The most comprehensive analysis of projected future regional economic development in relation to water requirements and supplies is contained in the reports of the Senate Select Committee on National Water Resources (13).

In these studies, the economic growth of the Nation was projected to continue to 1980 and 2000 at about the current rate. Various Federal agencies were asked to estimate the growth of water-using activities in each region and the increase in water requirements. These projections of regional economic activity and related water requirements represented an extension of past trends in each region, with only secondary consideration of the availability of water supplies.

To obtain a projected total water requirement, projected water losses from onsite uses and withdrawal uses were combined with flow requirements for dilution needed to maintain water quality under specified levels of waste treatment. This projected water requirement was compared in each region with streamflow available under a storage program which would provide the maximum sustained flow.

Chart 5 summarizes the results of this Senate Select Committee study. In the year 2000, the projected requirements would exceed maximum sustained flows in eight water resource regions. This comparison is based on a level of waste treatment about twice that which prevails now and a greatly expanded water storage and control program. If the expected

PRECIPITATION, RUNOFF, AND EVAPOTRANSPIRATION

By Water-Resource Regions

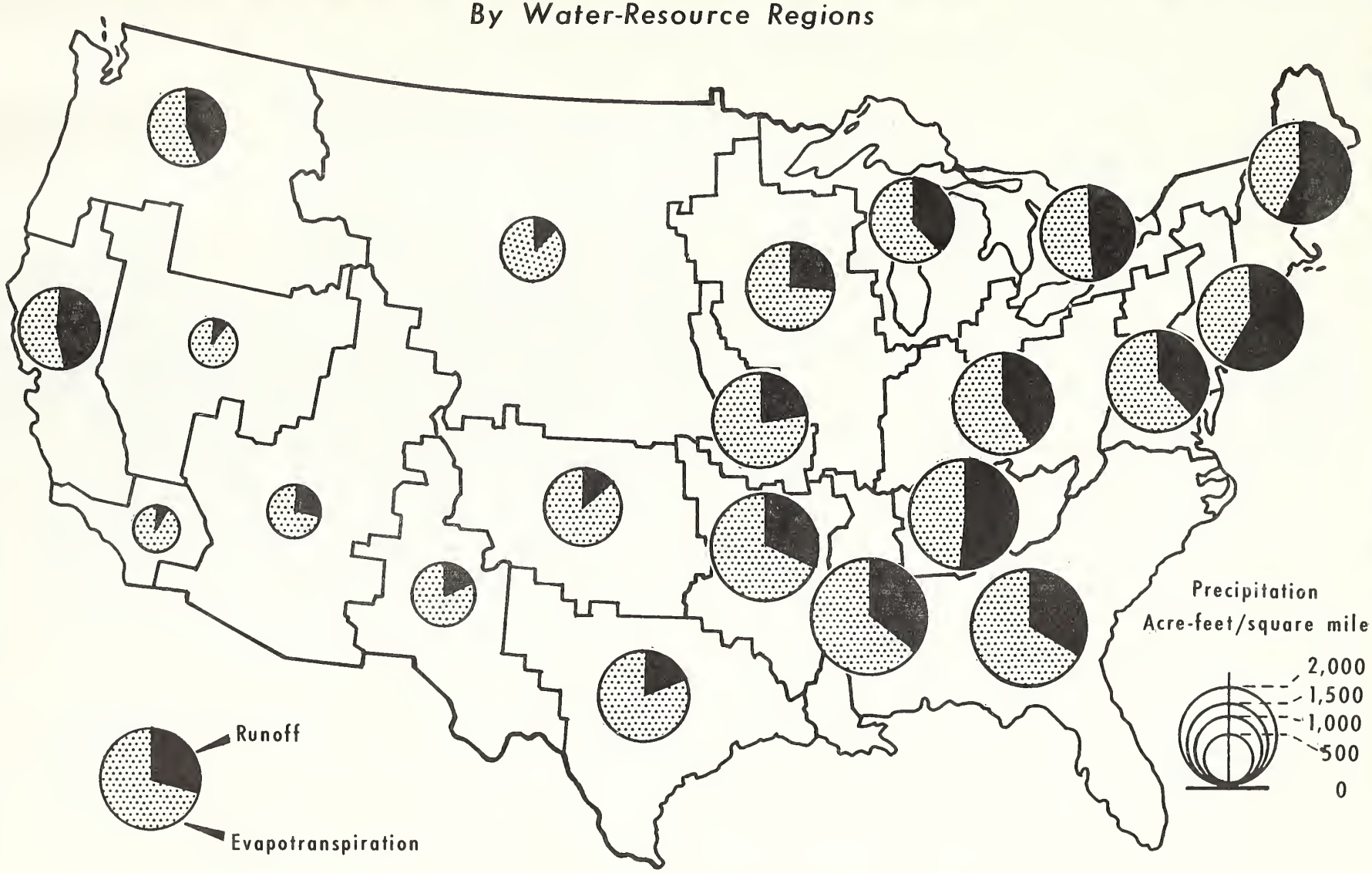


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Chart 4

PROJECTED WATER REQUIREMENTS FOR THE YEAR 2000

By Water-Resource Regions

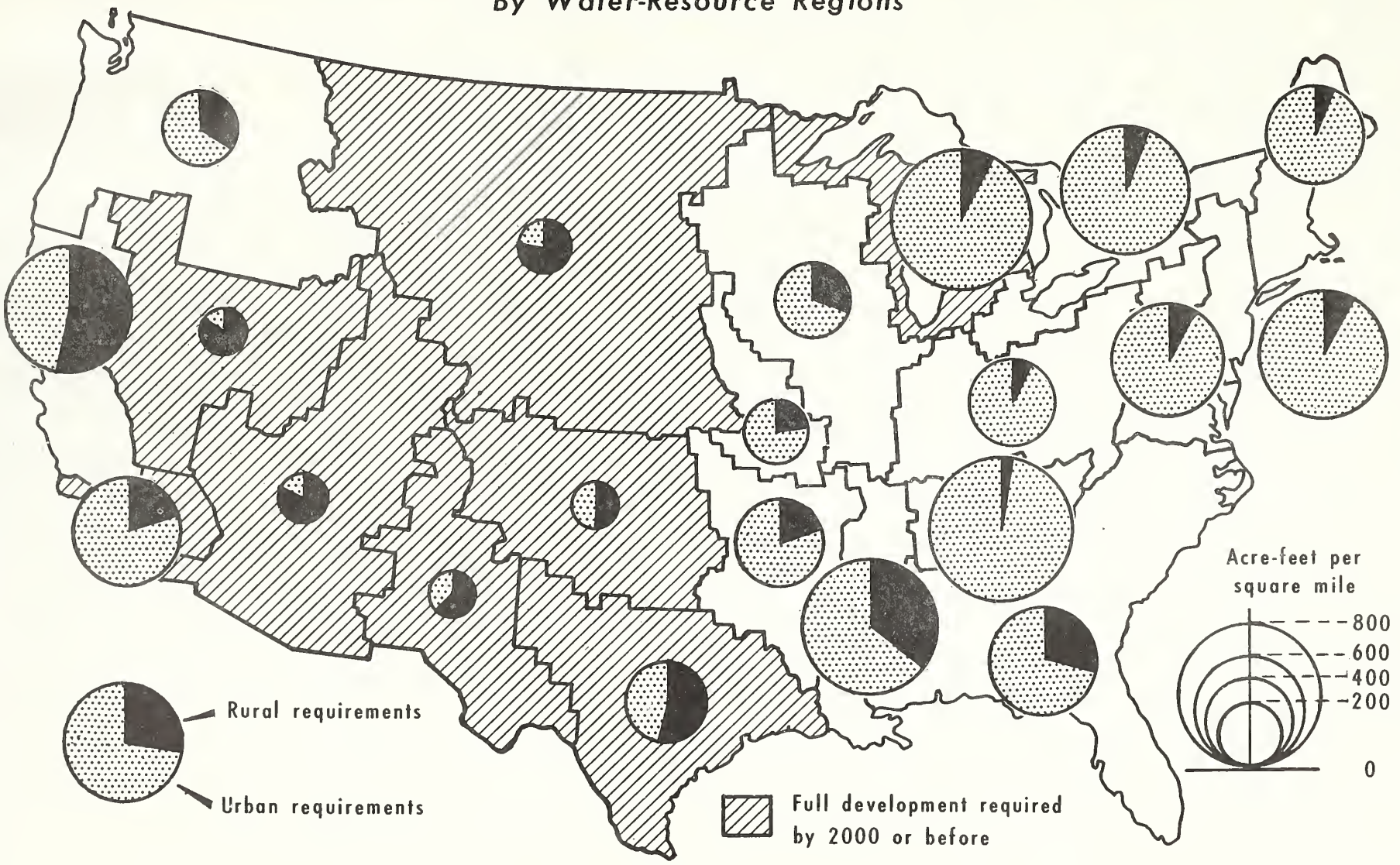

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Chart 5

level of waste treatment were not achieved or if the storage program were not installed, then more regions would fall short of projected requirements (11, 13).

The chart also shows the division of requirements between rural and urban uses. Rural uses combine losses from increased watershed treatment programs and losses from increased use of water for wildlife habitat and losses from farm uses. Urban uses include losses from increased water withdrawal for urban uses and the flows required for waste dilution.

In the East, requirements for urban uses exceed rural uses in all regions. In the water-short regions, requirements for rural uses exceed urban uses in all except two regions.

On the basis of their supply-demand studies, the Senate Select Committee's conclusions may be generalized as follows (14):

1. From a national viewpoint, we have an adequate supply of water so that water shortage need not inhibit national economic growth.

2. Water supply is likely to limit economic growth in a number of regions unless steps are taken to find solutions to problems of water shortages.

3. A positive program for development and use of our water supplies must be put into effect.

One of the most important steps recommended by the Committee was that the Federal Government, in cooperation with the States, should prepare by 1970 plans for comprehensive water development and management for all major river basins. Such plans should take into account prospective demands for all purposes served through water development and the ultimate need for optimum development of all water resources. Once prepared, the plans should be kept up to date.

These plans for major water regions would provide the framework for detailed plans for subbasin and project development in each region, and together for all regions would make up the Nation's water development program.

COMPREHENSIVE WATER DEVELOPMENT AND MANAGEMENT

In his message to Congress on Natural Resources in 1961, President Kennedy accepted the goal urged by the Senate Select Committee to develop comprehensive river basin plans by 1970. He also urged the establishment of river basin planning commissions for all major river basins. Subsequently, steps were taken to establish an ad hoc Water Resources Council to act in the interim while the Water Resources Planning Act was being considered by Congress (17).

In addition to preparing planning policies, procedures, and standards, the ad hoc Water Resources Council has prepared coordinated plans and budgets for covering the Nation with comprehensive framework plans for major basins or groups of basins by 1970.

As a guide to the basin-planning activities, tentative projections of national economic growth have been prepared for the ad hoc Water Resources Council (2, 18).

Chart 6 shows the growth in population and GNP from 1940 to 1960 and projections for the next 60 years. These projections indicate that population and the economy will continue to grow in the next 5 or 6 decades--probably much as it has in recent decades. The GNP projection for 2020 is more than $8\frac{1}{2}$ times 1960. This rate of expansion in the general economy is based on a projected growth in population to over 3 times 1960. The productivity of labor as measured by GNP per man-hour in 2020 is projected about 4 times the 1960 level.

The projections indicate that the farm component of the GNP would increase slightly over 2 times from 1960 to 2020. In contrast, the nonfarm components of the GNP are projected to increase over 9 times in the same period. These projections are slightly higher than those used in the Select Committee studies and thus may be expected to result in about the same or slightly higher water requirements.

Comprehensive framework plans include establishing long-run projections of economic activity, appraising the corresponding demands for water and related land, and estimating the quantity and quality of water that can be made available by water management programs.

Such a broad framework is essential for the formulation of a comprehensive development program for a basin. Basin programs and systems attempt to specify the nature, types, purposes, and development schedules of an integrated water-management plan for most advantageously achieving warranted objectives.

Economic studies are essential for the preparation of comprehensive framework plans and for providing background data for detailed studies of river basin systems and projects. Such studies involve an analysis of present and projected economic activity in the basin under study, analyses of the relationships of such economic activity to present and potential supplies of water and related land, and relationships to comparable developments in the rest of the Nation. The primary purpose of economic studies is to provide appraisals of the effects on economic growth and employment of different water projects and programs and permit comparisons between various project and nonproject alternatives.

Increased attention is being given to interbasin transfers as a possible solution to the problems of the water-short regions. A Special Subcommittee on Western Water Development has been created by the Senate Public Works Committee to study the utilization of water sources of the northern part of the continent to meet some of the needs of western Canada, United States, and Mexico (6).

GROSS NATIONAL PRODUCT, POPULATION, AND OUTPUT PER MAN-HOUR

1940, 1960, and Projections to 2020

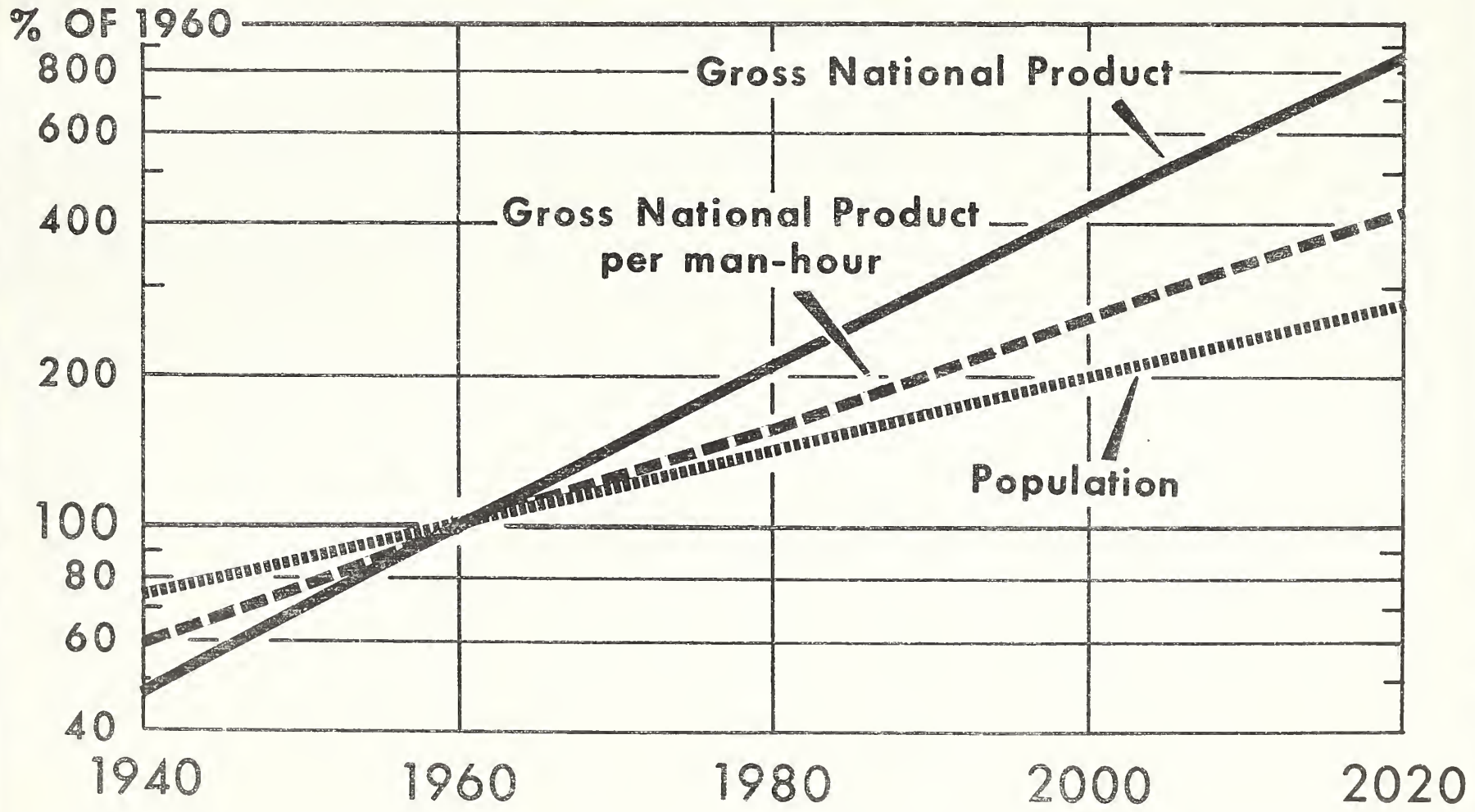

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Chart 6

To accomplish the objective of comprehensive plans for each major region, it will be necessary to relate regional economic development to national economic growth. We will need a system of analysis and the necessary data that will enable plans for each river basin to be evaluated in relation to other basins.

SUMMARY

Following are some suggested lines of action that emerge from the various studies of the water resource problem:

1. Federal and State water policies should be periodically reexamined in relation to the future water requirements and needs.

2. More comprehensive planning and management of water and related resources in the years ahead, including:

   a. Interregional analysis to indicate where development will make a maximum contribution to regional and national growth;

   b. Special attention to comprehensive planning at the international level;

   c. Improved allocation among uses, combined with improved technology in application and reuse of water; and

   d. Improved organizational and institutional arrangements.

3. Provide river system operations that are flexible in relation to future needs, as follows:

   a. Provide flexibility in constructed projects so they may meet changing needs;

   b. Provide flexibility in institutional arrangements; and

   c. Avoid irreversible decisions as to resource use and provide for future contingencies.

4. Plan and develop with a long-term perspective on:

   a. Reserving strategic sites;

   b. Acquiring adequate land for future development; and

   c. Planning for all purposes, but deferring full development of those purposes needed for future use.

5. These policy considerations and planning decisions must be supported by a program of basic and applied research.

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