WATER AND LAND RESOURCES--POTENTIALS AND REQUIREMENTS

Harry A. Steele 1/

This paper discusses the relation of land and water resources to economic activity, the magnitude and regional distribution of these resources, and their potentials in relation to projected requirements.

Since management and development of water resources involve long-term decisions--both investment and institutional--the decision makers need projections of long-term economic activity and related water requirements. The decision makers also need information on the effect of water resource development on the growth and location of economic activity. As pointed out by the Water Resources Council in its policies and standards, water policy is also concerned with preservation of the quality of the environment and with the well-being of all the people.(1)

Where conflicts arise, intangible values arising from "preservation" and "well-being" may often be more important than those from economic activity.

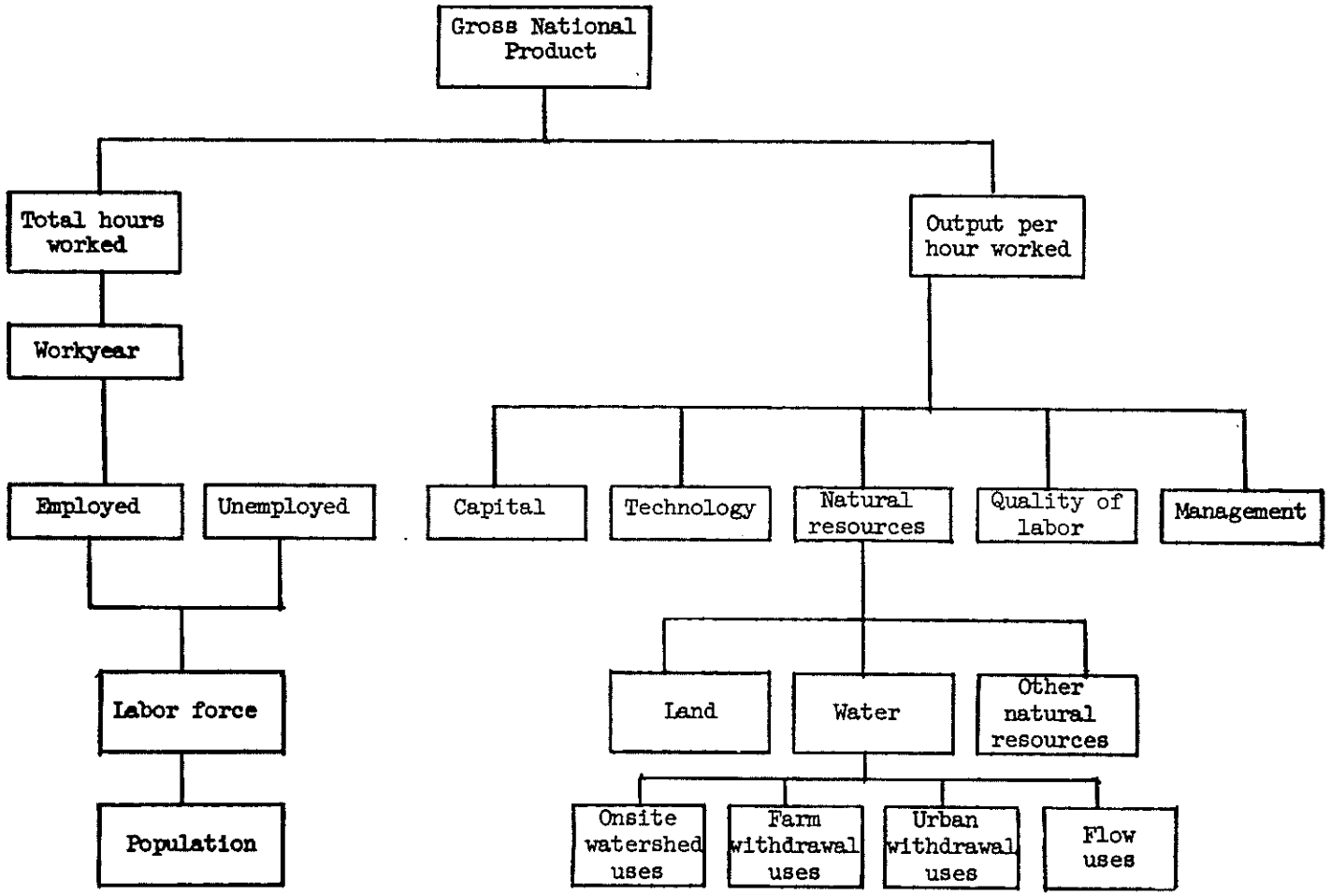
The consideration of any one use of water must be treated as an integral part of an analysis of water requirements for all uses with a common water supply. The shorter or more variable the supply, the more essential the need for taking account of all competing uses. Consideration of the water needs for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

The Nation is concerned with how variations in the occurrence of water resources--both location and time--can be offset by investment that results in local and regional development and in turn national development. National policy should avoid increasing one region's growth at the expense of other regions or retarding national growth. Here, we may encounter a conflict between national economic efficiency and the well-being of people in a particular region.

Economic growth is usually measured by an increase in the gross national product (GNP) which represents the market value of the national output of goods and services. The skills and knowledge of workers, the levels of management, capital and technology, and the available natural resources are important determinants of productivity and potential regional and national output (fig. 1). In the

1/ Director, National Resource Economics Division, Economic Research Service, U. S. Department of Agriculture, Washington, D. C.

PRODUCTION FACTORS DETERMINING GROSS NATIONAL PRODUCT



U. S. DEPARTMENT OF AGRICULTURE NEG. ERS 2805-64 (4) ECONOMIC RESEARCH SERVICE

Figure 1

long run the quantity and quality of natural resources are basic to the economy and determine the environment in which people live.

Figure 2 shows the relations between population, gross national product, and productivity for the period since World War II, and on a projected basis to the year 2020. (2) The GNP projection for 2020 is over 8½ times 1960. This rate of growth is based on a projected population growth to almost 3 times the 1960 figure and an increase in labor productivity of 4 times the 1960 level. The farm component of the GNP would increase slightly over 2 times. In contrast, the nonfarm component is projected to increase over 9 times. As a result, the rate of increase in water requirements for nonfarm uses will be much greater than for farm uses.

THE NATION'S WATER SUPPLY

Our annual water supply over the 48 mainland States amounts to 4.75 billion acre-feet of precipitation. About 3,380 million acre-feet, or 70 percent, of the total water supply is used by evapotranspiration from watershed lands. (3) (4)

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. (5) Associated with and influenced by the location of this primary farm activity were agriculturally related industries which make an important contribution to the GNP. 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 and related timber-based economic activities. (6) 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, 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 downstream from sedimentation are extensive. (8)

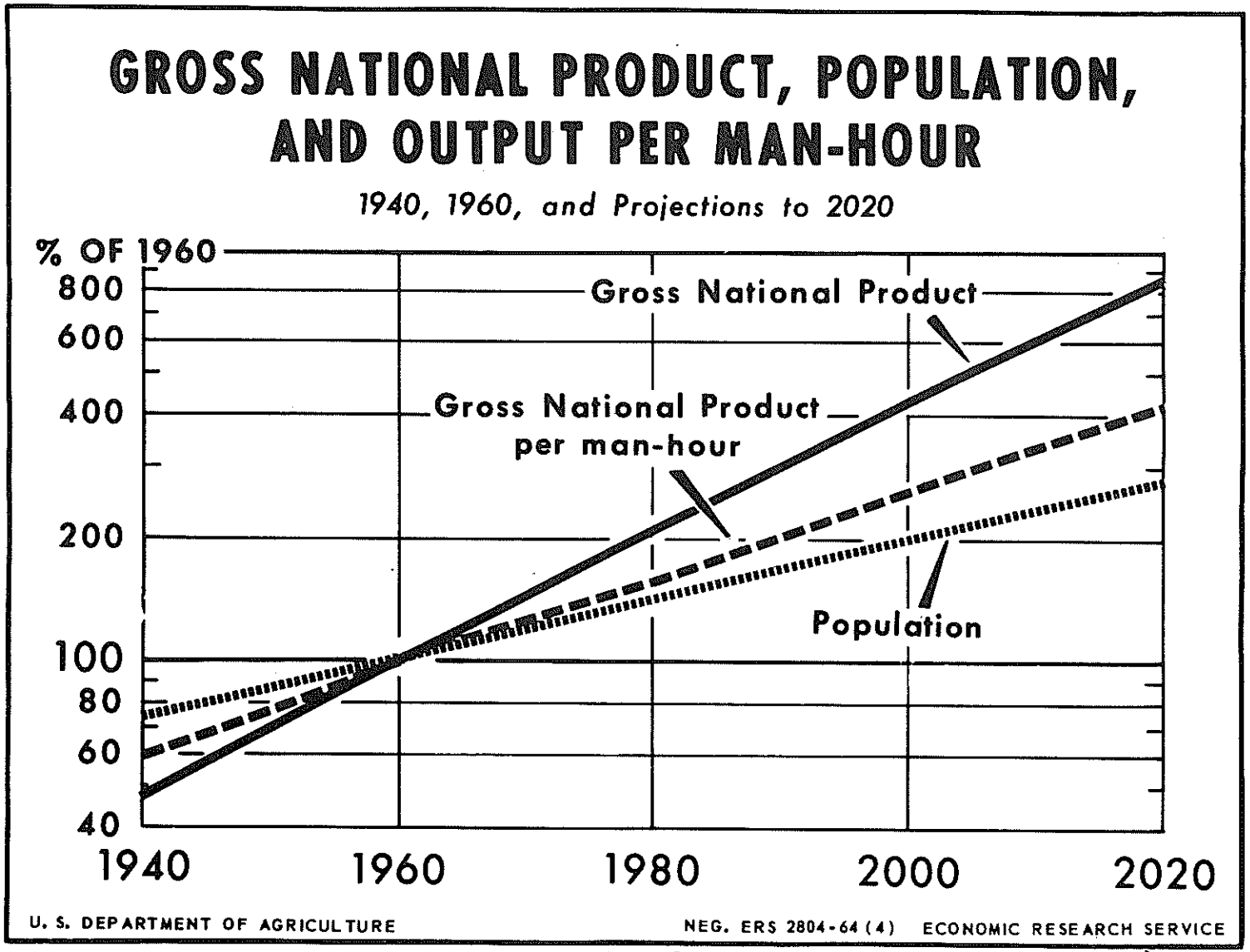

GROSS NATIONAL PRODUCT, POPULATION, AND OUTPUT PER MAN-HOUR
1940, 1960, and Projections to 2020
% OF 1960
800
600
400
200
100
80
60
40
Gross National Product
Gross National Product per man-hour
Population
1940
1960
1980
2000
2020
U. S. DEPARTMENT OF AGRICULTURE
NEG. ERS 2804-64 (4) ECONOMIC RESEARCH SERVICE

Figure 2

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.

Figure 3 shows how the 30 percent of our precipitation that constitutes our streamflow of 1,370 million acre-feet is used. (9) 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. (10) (11) (12) (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. Agriculturally related industries whose location is influenced by the location of irrigation contribute importantly to the GNP. There is considerable evidence that great improvement is possible in the efficiency of water use in irrigation. (14) Lack of economic incentives, legal obstacles, and lack of technical information, however, have hampered adoption of improved practices. Farm uses for irrigation, livestock, and household purposes account 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 greatly impaired.

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. In addition, much of the Nation's urban development and a substantial part of the farm production takes place on the flood plains of our rivers. Flood flows cause a loss in economic activity. Flood damages exceed $1 billion annually, of which about 40 percent is upstream and about 50 percent downstream. (15)

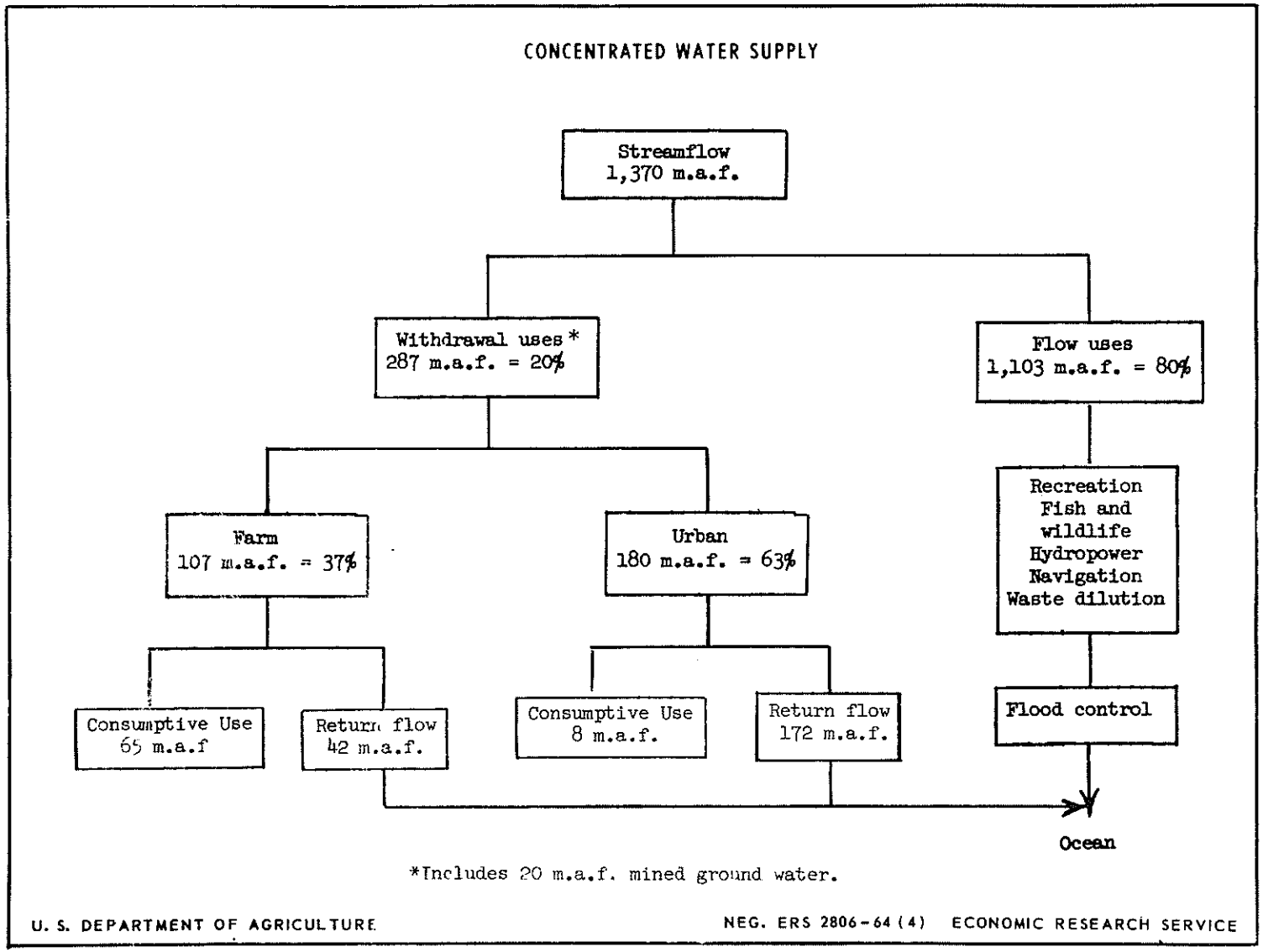

CONCENTRATED WATER SUPPLY
Streamflow
1,370 m.a.f.
Withdrawal uses *
287 m.a.f. = 20%
Flow uses
1,103 m.a.f. = 80%
Farm
107 m.a.f. = 37%
Urban
180 m.a.f. = 63%
Recreation
Fish and
wildlife
Hydropower
Navigation
Waste dilution
Consumptive Use
65 m.a.f
Return flow
42 m.a.f.
Consumptive Use
8 m.a.f.
Return flow
172 m.a.f.
Flood control
Ocean
*Includes 20 m.a.f. mined ground water.
U. S. DEPARTMENT OF AGRICULTURE
NEG. ERS 2806-64 (4) ECONOMIC RESEARCH SERVICE

Figure 3

These rough indications of the association of water use and economic activity pose some of the strategic questions and issues of water management policy to which an expanded program of research and comprehensive planning should be directed. Providing water management and land use systems for our river basins to meet the present and future needs of our economy for withdrawal and flow uses and to minimize flood damages is a responsibility involving all levels of government as well as private enterprise. Of equal importance to our economy is improving the quality of the water input into the river systems as it runs off watershed lands or is discharged as return flow after being diverted for agricultural and urban uses.

REGIONAL DISTRIBUTION OF WATER RESOURCES

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 water resources. So the water problem varies according to many local and regional factors.

Figure 4 shows the annual precipitation in acre-feet per square mile for water resource regions; 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, usable water supply from runoff in these regions is relatively low when measured on a unit area basis. (16)

Figure 5 shows the amount of water withdrawn or diverted for use by water resource regions. This pattern of water use varies greatly among the regions. For example, the Ohio River region and the Pacific Northwest both had total withdrawals of 27 million acre-feet, but in the Pacific Northwest about 89 percent was used for rural uses such as irrigation, livestock, and domestic purposes while in the Ohio only 1 percent was used for these rural purposes.

This regional variation in the availability and use 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.

For example, seven Western regions (excluding the Pacific Northwest and Central Pacific), with almost 50 percent 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. (17) If we examine employment in principal water-using industries, we find that these seven Western regions have about 10 percent of the U. S. total. (18) These seven regions have about 17 percent of the total population. (19)

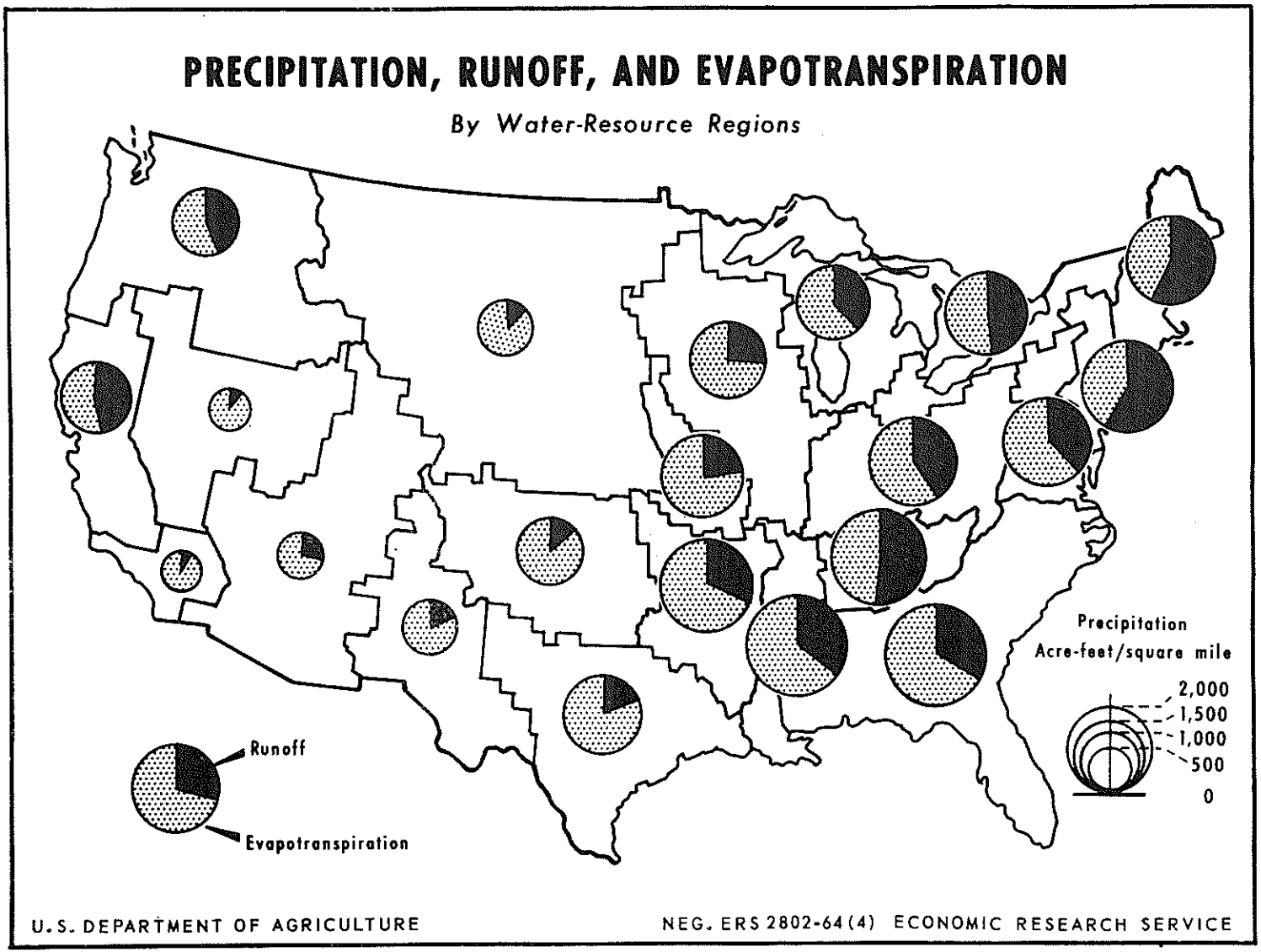

PRECIPITATION, RUNOFF, AND EVAPOTRANSPIRATION
By Water-Resource Regions
Precipitation
Acre-feet/square mile
2,000
1,500
1,000
500
0
Runoff
Evapotranspiration
U.S. DEPARTMENT OF AGRICULTURE
NEG. ERS 2802-64(4) ECONOMIC RESEARCH SERVICE

Figure 4

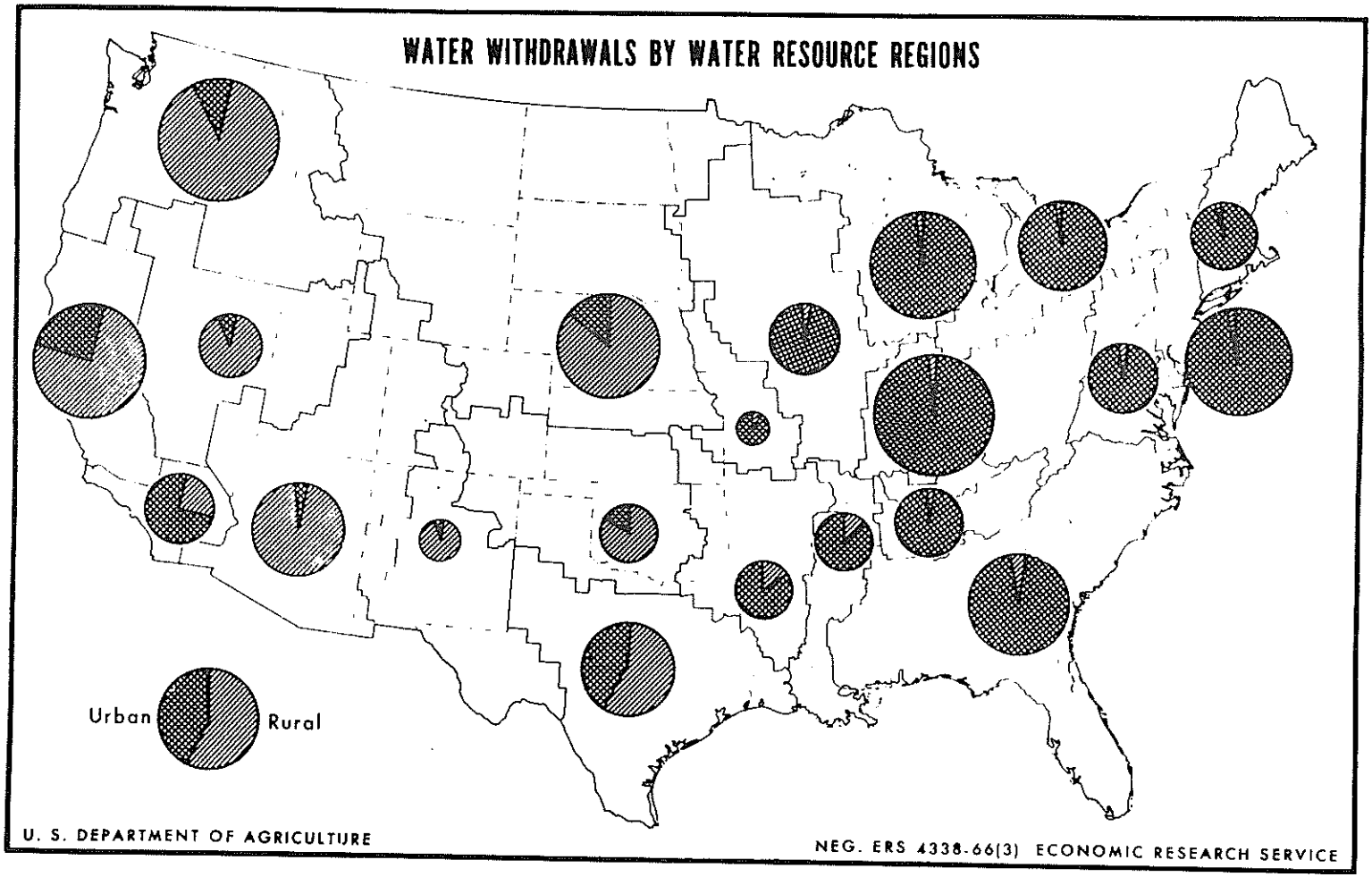

WATER WITHDRAWALS BY WATER RESOURCE REGIONS
Urban
Rural
U. S. DEPARTMENT OF AGRICULTURE
NEG. ERS 4338-66(3) ECONOMIC RESEARCH SERVICE

Figure 5

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 NATION'S LAND RESOURCE

There are 640 million acres of land in capability classes I, II, and III (fig. 6) which are physically suitable for regular cultivation. Currently, about 113 million acres of this land is in pasture and range and could be converted to crop uses if necessary, although some might require draining or other improvements. Clearing and other improvements likewise could make available for crop production about 125 million acres of forested land in these capability classes. (20)

Approximately 169 million acres of class IV land is suited for occasional cultivation at high cost and with intensive conservation treatment. Only about 49 million acres of class IV land is currently used for crops.

Thus, we have about 800 million acres that might be considered potential cropland. A very rough estimate indicates that as much as 600 million acres might be developed for crops by shifts from pasture, forests, and other uses. There would be a wide range in cost of development of these lands for crop use. Some of these lands would be of low productivity. The opportunity costs in terms of loss of timber, production, or increased erosion might be quite high. At present, we are using less than 400 million acres of cropland.

REGIONAL DISTRIBUTION OF LAND RESOURCES

The distribution of potential cropland in relation to total area of each region is shown on figure 7. There is a very uneven distribution of potential cropland among the water resource regions. Much of our cropland potential is concentrated in the Great Plains, North Central and Southern parts of the country.

PRODUCTIVITY

There are many factors that must be estimated or assumed in projecting future requirements for water and land resources. I have discussed projections of population, labor productivity, and the GNP, but another important factor is the productivity of our land and water resources which is increasing rapidly as a result of improvements in technology. One of the most striking illustrations of this is the

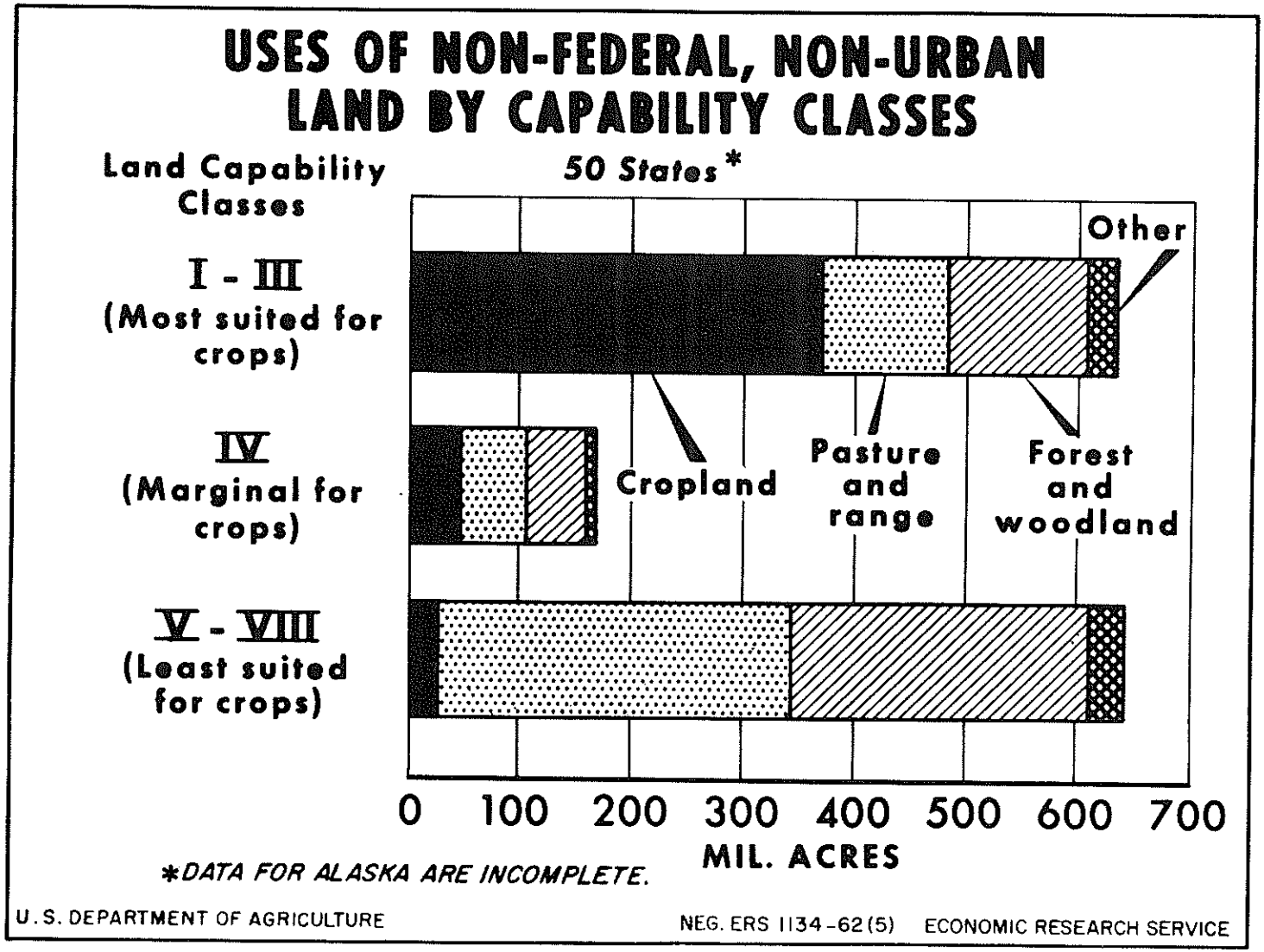

USES OF NON-FEDERAL, NON-URBAN LAND BY CAPABILITY CLASSES
Land Capability Classes
50 States*
I - III
(Most suited for crops)
IV
(Marginal for crops)
V - VIII
(Least suited for crops)
Other
Cropland
Pasture and range
Forest and woodland
0 100 200 300 400 500 600 700
MIL. ACRES
*DATA FOR ALASKA ARE INCOMPLETE.
U.S. DEPARTMENT OF AGRICULTURE
NEG. ERS 1134-62(5) ECONOMIC RESEARCH SERVICE

Figure 6

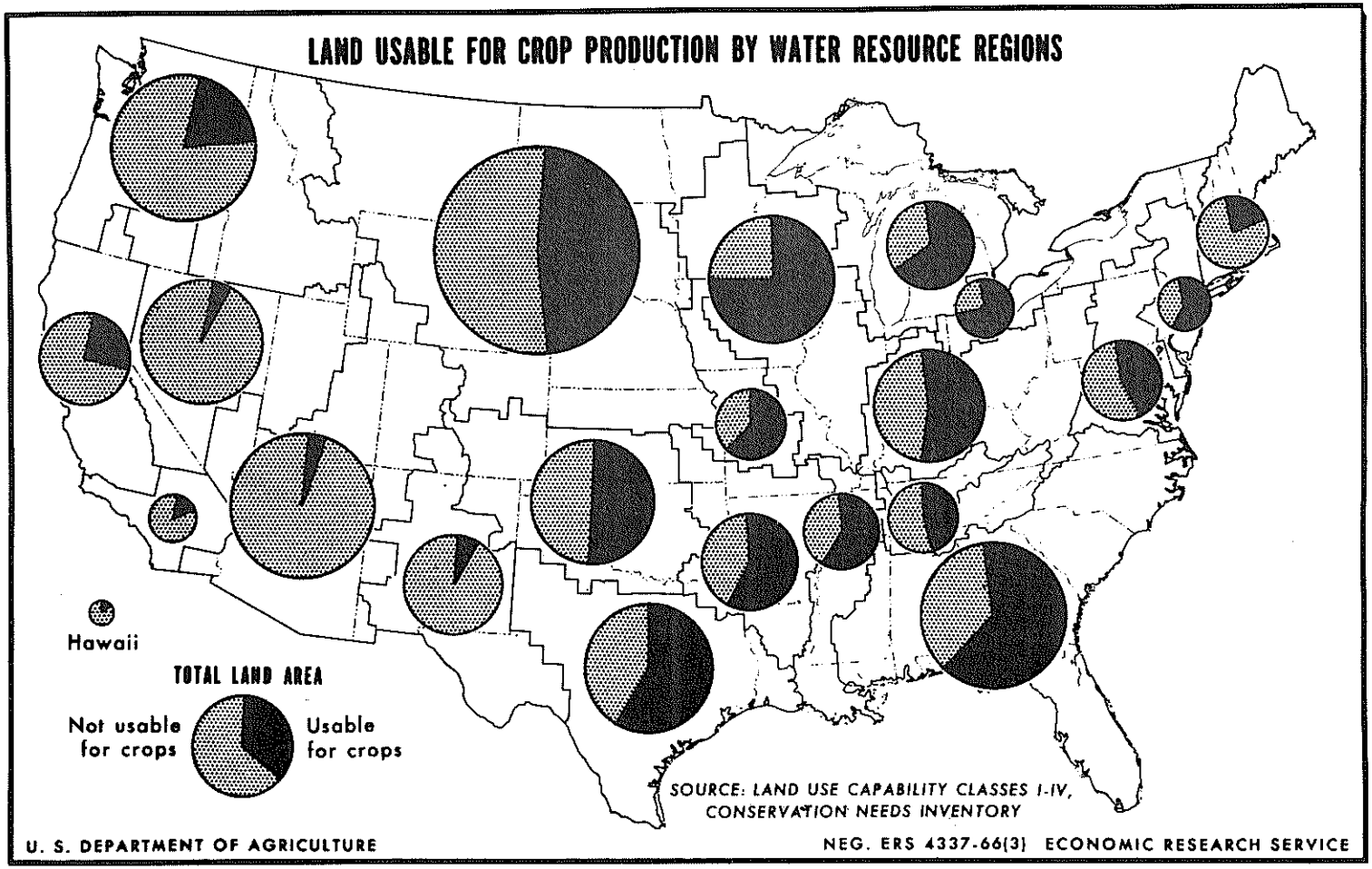

LAND USABLE FOR CROP PRODUCTION BY WATER RESOURCE REGIONS
Hawaii
TOTAL LAND AREA
Not usable for crops
Usable for crops
SOURCE: LAND USE CAPABILITY CLASSES I-IV, CONSERVATION NEEDS INVENTORY
U. S. DEPARTMENT OF AGRICULTURE
NEG. ERS 4337-66(3) ECONOMIC RESEARCH SERVICE

Figure 7

trend in crop production per acre (fig. 8). Since 1950, crop production per acre has increased 46 percent, more than offsetting the decrease in cropland, with the result that we are producing more on fewer acres.

MODEL FOR PROJECTING REQUIREMENTS

Figure 9 outlines in very simplified form some of the factors involved in projecting future requirements for land and water use. Population growth, consumer income and demand, and foreign trade policy are shown as the principal determinants of demand for land and water resources. The circles on the chart indicate important factors in converting resource use in products and services. Crop and timber yields and the efficiency of feeding livestock or irrigating land are illustrative of these factors.

In 1962, the Department of Agriculture's Land and Water Policy Committee used this model to estimate land use requirements for 1980. (21) Its report indicated that productivity would increase fast enough so that cropland needed in 1980 would be about 50 million acres less than was counted as cropland in the 1959 census. This happened to be about the same acreage as was and still is held out of production by Government programs. In this calculation the Committee assumed that various factors that had been bringing about an increase in crop yields per acre would continue. This included a continuation of the expansion in irrigated acreage. As a result of these considerations, policy was directed toward a continuing program of cropland diversion and a program to expand other rural income-producing possibilities such as recreation.

In 1965, the Committee reviewed its 1962 work and concluded that although there were several changes in the outlook for different factors affecting resource requirements some of these were offsetting and there was no basis to change the conclusions arrived at in 1962.

Now consideration is being given to a Food for Freedom policy that could expand export requirements and thus result in a corresponding requirement for additional crop production. (22) With a model such as I have outlined it is possible to calculate the effect of such policy proposals on land and water use.

In my 30 years of Government service I have seen great shifts in land water requirements from depression to wartime shortages as well as major changes regarding export policy. The look back at past experience as well as this attempt to look ahead indicate the problem of predicting the future with any great degree of certainty and the need for maintaining flexibility in public policy and avoiding irreversible decisions.

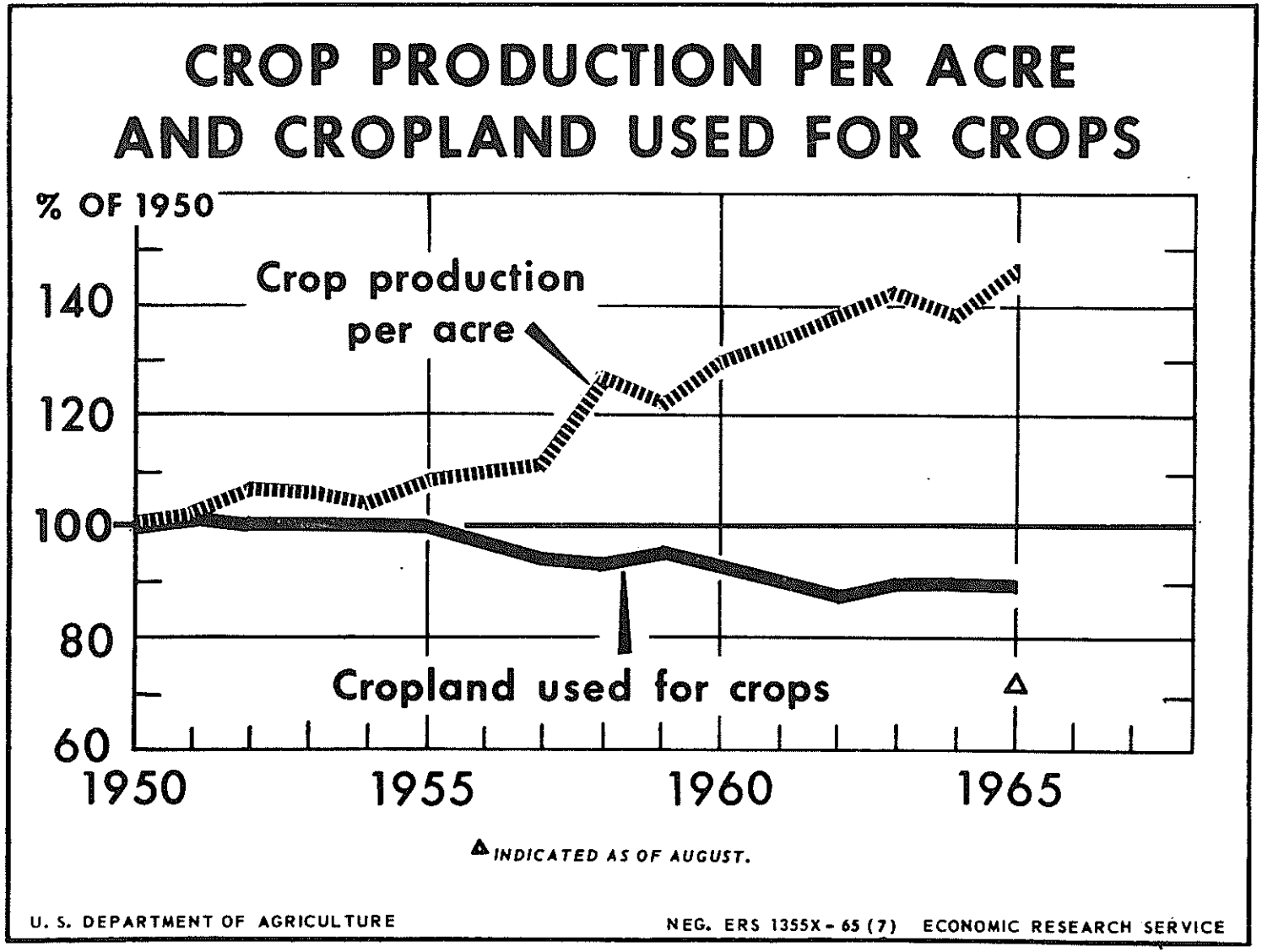

CROP PRODUCTION PER ACRE
AND CROPLAND USED FOR CROPS
% OF 1950
140
120
100
80
60
Crop production
per acre
Cropland used for crops
Δ
1950
1955
1960
1965
Δ INDICATED AS OF AUGUST.
U. S. DEPARTMENT OF AGRICULTURE
NEG. ERS 1355X - 65 (7) ECONOMIC RESEARCH SERVICE

Figure 8

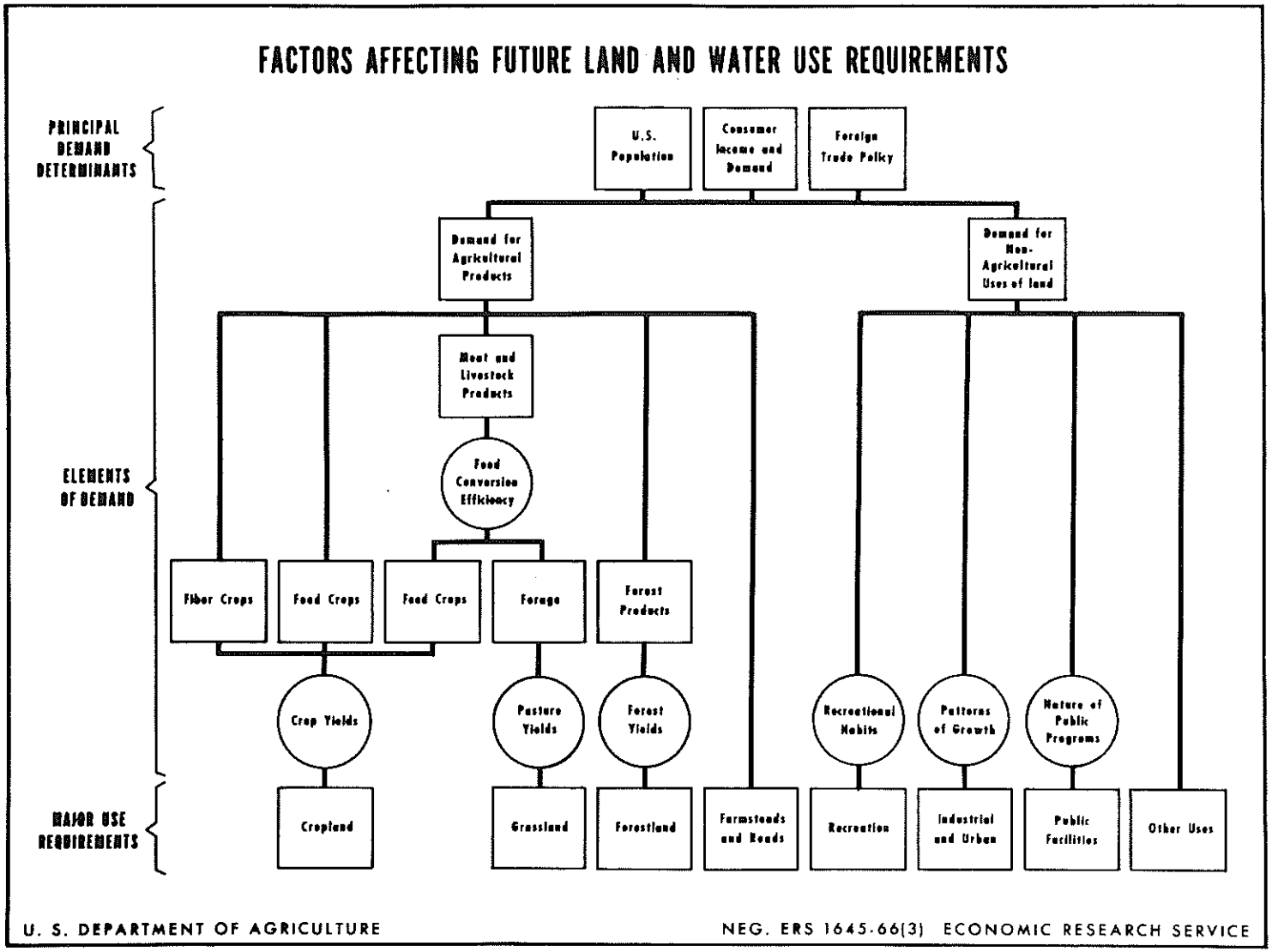

FACTORS AFFECTING FUTURE LAND AND WATER USE REQUIREMENTS
PRINCIPAL DEMAND DETERMINANTS
ELEMENTS OF DEMAND
MAJOR USE REQUIREMENTS
U.S. Population
Consumer Income and Demand
Foreign Trade Policy
Demand for Agricultural Products
Demand for Non-Agricultural Uses of land
Meat and Livestock Products
Food Conversion Efficiency
Fiber Crops
Food Crops
Food Crops
Forage
Forest Products
Crop Yields
Pasture Yields
Forest Yields
Recreational Habits
Patterns of Growth
Nature of Public Programs
Cropland
Grassland
Forestland
Farmsteads and Roads
Recreation
Industrial and Urban
Public Facilities
Other Uses
U. S. DEPARTMENT OF AGRICULTURE
NEG. ERS 1645-66(3) ECONOMIC RESEARCH SERVICE

Figure 9

As a Nation we are fortunate to have such a large cropland potential. Our land and water resources are valuable national assets which must be managed and conserved for the future. The Nation should make provision for adequate land and water reserves which could be shifted to crop use in case of domestic need or to meet international policy objectives.

REFERENCES

1. "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources," Senate Document No. 97, 87th Congress, 2d Session, May 29, 1962.

2. Preliminary projections by the Economics Task Force of the Water Resources Council, July 1963. There have been minor revisions in these projections by the Task Force.

3. Ackerman, Edward A. and George O. Lof, "Technology in American Water Development," Johns Hopkins Press, 1959. 710 pp.

4. National Academy of Sciences--National Research Council, "Water Resources - A Report to the Committee on Natural Resources," NAS-NRC Pub. 1000-B, Washington, D. C., 1962. 35 pp. (Abel Wolman, Chairman of the Water Resources Study).

5. Select Committee on National Water Resources, "Water Resources Activities in the United States--Land and Water Potentials and Future Requirements for Water," Committee Print No. 12, U. S. Senate, Dec. 1959. 86th Cong., 1st Sess.

6. Hair, Dwight, "The Economic Importance of Timber in the United States," U. S. Dept. Agr., Forest Service, Misc. Pub. 941, July 1963.

7. NAS-NRC Pub. 1000-B, 1962, op. cit.

8. Steele, Harry A., "Research on Water Resources in the U. S. Department of Agriculture," presented at Interstate Conference on Water Problems, Chicago, Illinois, Dec. 1963.

9. NAS-NRC Pub. 1000-B, 1962, op. cit.

10. Ackerman and Lof, op. cit.

11. MacKichan, K. A. and J. C. Kammerer, "Estimated Use of Water in the United States, 1960," U. S. Dept. of the Int., Geological Survey Circular 456, Washington, D. C., 1961.

12. NAS-NRC Pub. 1000-B, 1962, op. cit.

13. Select Committee on National Water Resources, "Water Resources Activities in the United States--Water Supply and Demand," Committee Print No. 32, U. S. Senate, 86th Cong., 2d Sess., August 1960.

14. Select Committee on National Water Resources, Committee Print No. 12, op. cit.

15. Steele, Harry A., "Research on Water Resources in the U. S. Department of Agriculture," op. cit.

16. Select Committee on National Water Resources, "Water Resources Activities in the United States--Estimated Water Requirements for Agricultural Purposes and Their Effects on Water Supplies," Committee Print No. 13, U. S. Senate, 86th Cong., 2d Sess., December 1959.

17. Select Committee on National Water Resources, Committee Print No. 12, op. cit.

18. Select Committee on National Water Resources, "Water Resources Activities in the United States--Future Water Requirements of Principal Water-Using Industries," Committee Print No. 8, U. S. Senate, 86th Cong., 2d Sess., April 1960.

19. Select Committee on National Water Resources, "Water Resources Activities in the United States--Population Projections and Economic Assumptions," Committee Print No. 5, U. S. Senate, 86th Cong., 2d Sess., March 1960.

20. Steele, Harry A. and Norman E. Landgren, "Demands for Land for Agriculture--Past, Present, and Future," address at the Homestead Centennial Symposium, Lincoln, Nebraska, June 12, 1962.

21. The details of this model may be found in "Land and Water Resources: A Policy Guide," U. S. Department of Agriculture, Washington, D. C., September 1962.

22. Daly, R. F. and A. C. Egbert, "A Look Ahead for Food and Agriculture," Agricultural Economics Research, Vol. XVIII, No. 1, January 1966.