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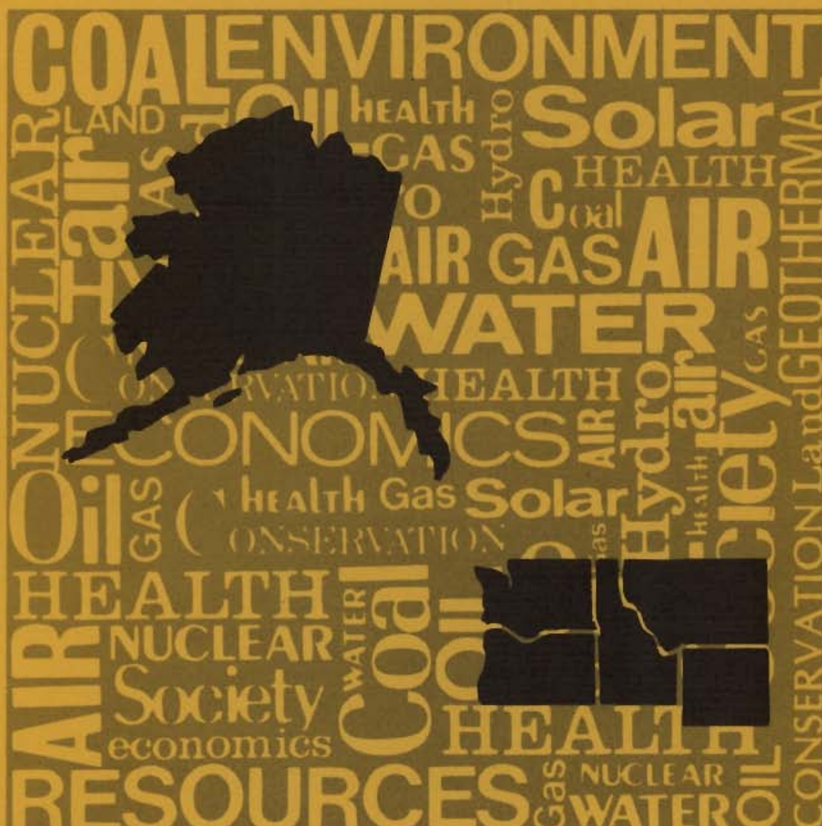
Pacific Northwest Energy Related
Regional Assessment Program

Systems Methodology for Assessing the Demographic Implications of Energy Development



September 1976

Prepared for the U.S. Energy
Research and Development Administration
under contract AT(45-1):1830

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ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
Under Contract E(45-1)-1830

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151
Price: Printed Copy $5.50; Microfiche $2.25

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SYSTEMS METHODOLOGY FOR ASSESSING THE DEMOGRAPHIC IMPLICATIONS OF ENERGY DEVELOPMENT

by
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September 1976

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SUMMARY

The objective of the Pacific Northwest Regional Assessment Program is to estimate changes in the Region's environmental, socioeconomic, and health status that could result from various energy development or conservation scenarios. Battelle, Pacific Northwest Laboratories, uses a dynamic simulation model to help evaluate pertinent issues in the Northwest (Alaska, Idaho, Montana, Oregon, Washington, and Wyoming). One of the primary sectors of this model is the demographic sector, which provides the needed demographic information to other model sectors. Specifically, it traces the effects of various energy development scenarios on employment and population growth. The demographic sector simulates the interactions among the population, birth rate, death rate, net migration rate, and jobs available in the Region from 1960 to 2020. The population is disaggregated so that age-specific birth and death rates, age-specific propensity to migrate, and age-specific labor force participation rates can be used.

The following factors relative to the trends in the Pacific Northwest are incorporated in the demographic sector of the model:

- The population is expected to increase due to the high percentage of people who will enter the ages of highest birth rates and also because of increases in employment opportunities.
- In response to the increases in employment opportunities the labor supply will increase in the next 20 years.
- Death rates will remain constant.

The output for the demographic sector of the model is a report generated every 5 years. It includes the three components of population change: births, deaths, and net migration for the previous 5 years. It also notes the percent change in population, births and deaths per 1000 people, age distribution, labor force, unemployment rate, and number of households.

The demographic sector is still in its developmental stage. Further work may include making birth rates and labor force participation functions of

regional unemployment. The number of household size classifications may be reduced from six to two or three; and the demographic sector of the model should be disaggregated to include state subregions.

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INTRODUCTION

The Pacific Northwest (defined in this report to include the states of Alaska, Montana, and Wyoming as well as Washington, Oregon and Idaho) contains a large share of the domestic fossil energy resources of the United States. The increasing utilization of fossil fuels prior to development of more advanced energy supply technologies will change the Region's natural environment, economic development patterns, and life style. The objective of the Pacific Northwest Regional Assessment Program is to establish and implement an integrated analytical assessment program to evaluate changes that could result from various energy development or conservation scenarios.

The majority of such energy-related actions characteristically have time scales measured in decades--long planning and implementing periods are involved and the life cycle of such actions span several decades. Similar time scales therefore apply to the magnitude of the environmental, health, socioeconomic and demographic consequences. The cumulative effect of small increments of stress undoubtedly extend this time even further. For these reasons, the time horizon of the analysis extends to the year 2020.

After considering various approaches to integrated assessment of actions with long-term consequences at a regional level, Battelle, Pacific Northwest Laboratories, has included a dynamic simulation model as part of its overall Regional Assessment Program. This model has been structured within a framework of ten sectors (Figure 1). Each sector involves its own submodels that receive information either from outside the model as "exogenous inputs" or from other sector submodels.

As shown in Figure 1, there are three primary "driving" sectors--economics, energy and demography. The dynamic results from these sectors in turn cause the primary changes in "driven" sectors at the right of the figure. These sectors can also generate constraints (e.g., air quality limits) that would constrain developments.

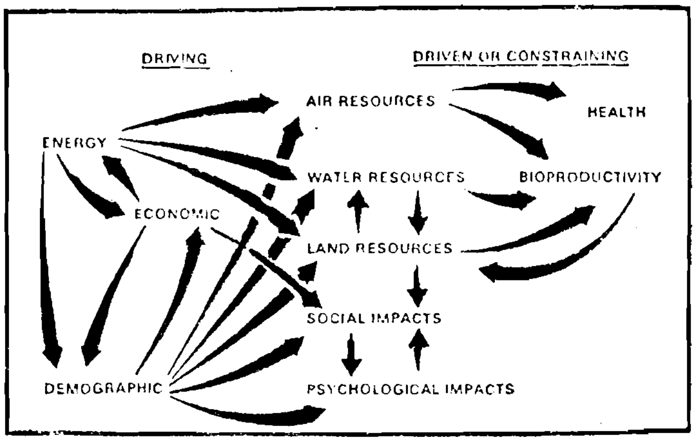


FIGURE 1. Analytical Framework of the Pacific Northwest Regional Assessment Program Simulation Model

Energy-related development activities in the relatively sparsely populated areas of the Pacific Northwest may result in significant demographic changes, particularly at a subregional scale. Although demographic forecasts are routinely prepared by state and Federal agencies, few, if any, of these consider possible perturbations of major energy development activities and changes in the relative availability or price of energy. In addition, demographic changes may more significantly stress the environmental quality and the socioeconomic conditions of an area than the energy facility per se. As a result, the Pacific Northwest simulation model both drives and, in turn, is driven by the demographic sector.

There are three purposes for the demographic sector:

1. To provide consistent demographic information to other model sectors to help determine energy demand, water usage, land requirements and health impacts.
2. To provide information about the size and occupational distribution of the labor force to the economic sector.
3. To trace the effects of various energy development scenarios on regional unemployment, unemployment within various industrial categories, and regional population growth.

At the present time the demographic sector of the model is coded and operating using the GASP IV simulation language in conjunction with the other sectors of the model which are coded. However, the demographic sector does not interact directly with any of these sectors. As a result, all inputs required from these other sectors are simulated using exogenous time-dependent table functions. Consequently, the demographic sector has been de-emphasized until the other sectors are more fully structured and the inputs required by them are better understood. As a result, some of the data in the demographic sector are for the Nation as a whole and have not been verified for the Region. In other cases, exogeneous data are constant over time although they should be varied with time to give accurate results. For these reasons, the demographic sector of the model is still in its developmental stage.

The following pages consider the major factors in the demographic system of the Pacific Northwest, a general description of the demographic sector of the dynamics simulation model, the equations used, and a sample of the demographic sector output. The final section deals with suggestions for further work. Appendix A is a compilation of population data for the Pacific Northwest Region.

FACTORS IN THE DEMOGRAPHIC SYSTEM

Before describing the demographic sector of the dynamic simulation model, features and trends of the Pacific Northwest Region are discussed. These include population growth, birth and death rates, age distribution, labor force and employment.

POPULATION GROWTH

During the period from 1970 to 1975, the population of states in the Pacific Northwest Region generally grew at a rate significantly above the national average. As shown in Table 1, all states in the Region, except Washington, ranked among the top 15 based on percent change from 1970 to 1975.

TABLE 1. Population Change 1970-1975

State	Population April 1, 1970	Population July 1, 1975 (Provisional)	Percent Change 1970-1975	National Ranking by Percent Change
Alaska	303,000	352,000	20.8	4
Idaho	713,000	820,000	14.9	6
Montana	694,000	748,000	7.7	15
Oregon	2,092,000	2,288,000	9.5	13
Washington	3,413,000	3,544,000	4.5	32
Wyoming	332,000	374,000	12.5	10
U.S.	203,304,000	213,121,000	5.1	-

Source: Bureau of the Census, 1975 (Reference 1).

The population of the Pacific Northwest states is expected to continue to grow throughout the time horizon of the model analysis. Figure 2 shows a low, high, and average population forecast derived from the most recent population data prepared by the individual states in the region and the Bonneville Power Administration. The data for Figure 2 are presented in Appendix A, along with similar graphs for each state in the Region. The estimated 1975 population

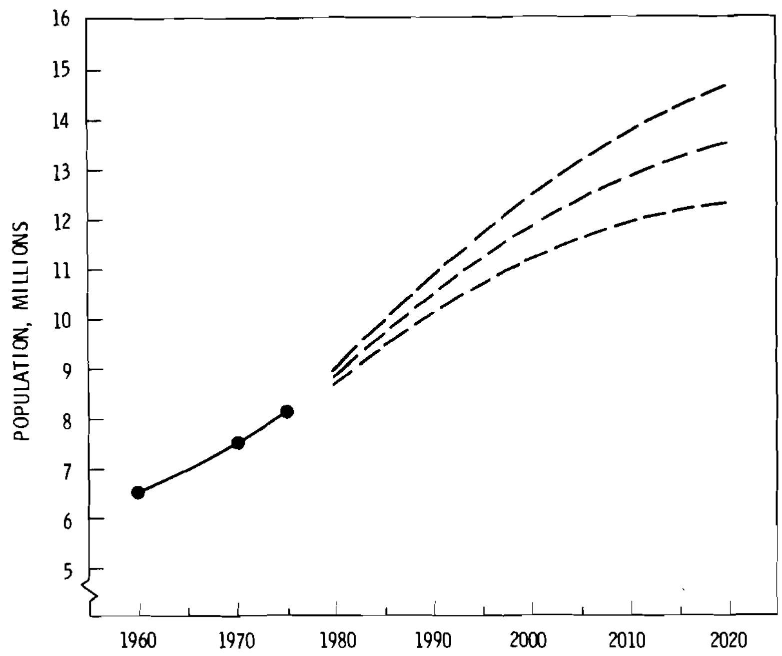


FIGURE 2. Derived Low, High, and Average Population Projection and Extrapolation for Pacific Northwest States

for the six-state Region was 8,126,000.[1] As shown in Figure 2, the population is likely to increase to between 12 and 13.5 million by the year 2020. While some of this will come from natural increase (approximately 1% per year), the larger percentage will be due to migration.

A number of factors are responsible for this anticipated in-migration. In addition to the energy resources which are likely to be developed, the Northwest enjoys relatively inexpensive electrical power, has great potential for expanded agricultural production, and offers a generally rural lifestyle that has become an attractive alternative to more urbanized regions.

BIRTH RATES

The birth rate in the United States and the Pacific Northwest Region has shown a steady decline for the past 15 years. As shown in Table 2, the national rate of live births per 1000 population has dropped from 23.7 in 1960 to 14.8 in 1975 with the states in the Region showing a similar decrease.

TABLE 2. Live Birth Rate Per 1000 Population

State	1960	1965	1970	1971	1975
Alaska	33.4	27.9	24.5	22.9	-
Idaho	25.7	19.3	19.5	19.1	-
Montana	25.9	19.3	17.9	17.2	-
Oregon	21.7	17.4	17.3	15.8	-
Washington	22.9	17.7	17.9	15.7	-
Wyoming	25.8	19.3	19.1	17.4	-
U.S.	23.7	19.4	18.2	17.3	14.8

Sources: Statistical Abstracts 1973, p. 53 (Reference 2).
Vital Statistics 1976, p. 1 (Reference 3).

Recent research has suggested that the historical decline shown in Table 2 may be reversed in the years ahead. It has been suggested in a recent study that the country will experience a birth rate increase in the next few years. According to the study the low birth rates in the 1960's and early 1970's were caused in large part by a trend to postpone marriage and child-bearing. In addition, the women born during the peak baby boom years of the middle and late 1950's will be reaching their prime reproduction ages.[4, p.693]

DEATH RATES

In contrast to birth rates, death rates have remained relatively constant during the past 15 years. As shown in Table 3, nationally the death rate per 1000 population has dropped from 9.5 in 1960 to 9.3 in 1970, with the Pacific Northwest states showing similar behavior.

AGE DISTRIBUTION

An age-sex pyramid provides much information about the social attributes of the inhabitants concerned. The age distribution for the Pacific Northwest states is illustrated in the age-sex pyramid shown in Figure 3.

TABLE 3. Death Rate Per 1000 Population

State	1960	1965	1970	1971
Alaska	5.8	5.3	4.8	5.0
Idaho	8.1	8.6	8.3	8.4
Montana	9.7	9.3	9.4	9.5
Oregon	9.5	9.6	9.3	9.3
Washington	9.3	9.2	8.9	8.8
Wyoming	8.5	8.3	8.9	8.9
U.S.	9.5	9.4	9.4	9.3

Source: Statistical Abstracts 1973, p. 61 (Reference 2).

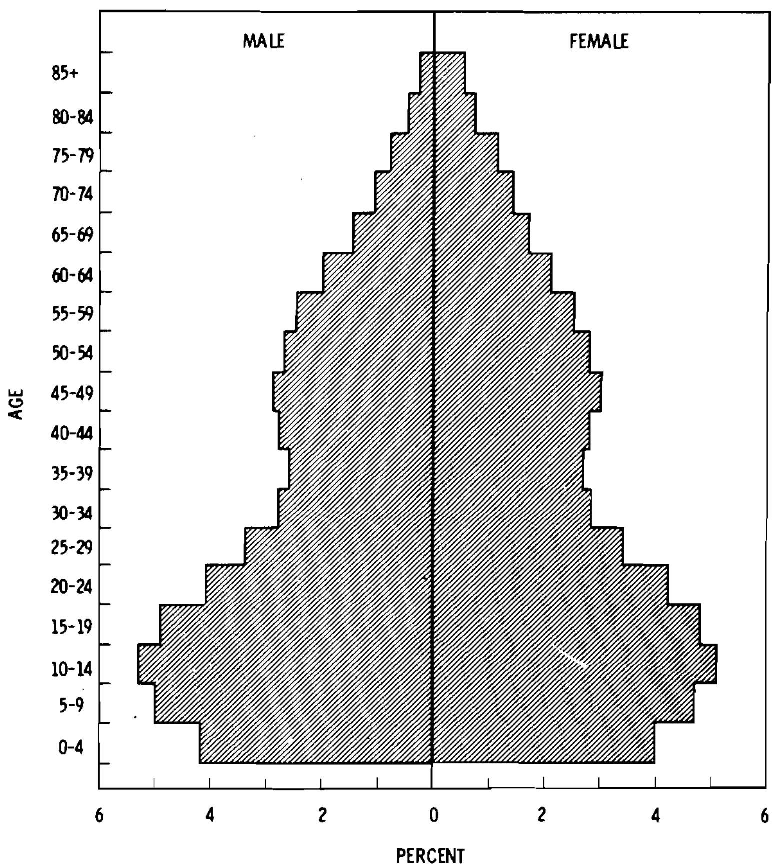


FIGURE 3. 1970 Age Distribution for Pacific Northwest States. Source: Bureau of the Census, 1970 (Reference 7).

The most notable feature of this pyramid is the relatively high percentage of people in the lower age categories. During the period from 1970 to 1990, people in the four lower age groups are entering the ages of highest birth rates and highest household formation rates. If birthrates and family formation rates remain constant or increase, there will be an increase in births and new families in the Region.

This increase in young people also points to an increase in the regional labor supply. At the same time the people aged 1 through 20 are entering the period of highest labor force participation the people aged 45 to 65 are generally retiring and leaving the labor force. As shown in Figure 3, in the next 20 years, the number of people entering the labor force will exceed the number of older people leaving, further increasing the labor supply in the Region.

LABOR FORCE PARTICIPATION

An increasing percentage of women are entering the labor market and finding jobs. This trend is especially strong among the younger age groups. Nationally this trend has been evolving since World War II. Figure 4 shows the national labor force participation rate for wives with school age children for the past 30 years. The female labor force participation rate for Washington for 1960 and 1970 is shown in Figure 5. This behavior is typical for all the Northwest states.

On the other hand, the male labor force participation rate has remained quite stable during this period. There has been a slight trend toward earlier retirement which has reduced the labor force participation for the ages 50 through 65. Figure 6 presents the behavior of the male labor force participation rate in Washington for 1960 and 1970.

EMPLOYMENT

The employed civilian labor force for the six states in the Region for 1960 and 1970 are listed in Table 4 along with the resulting percentage change.

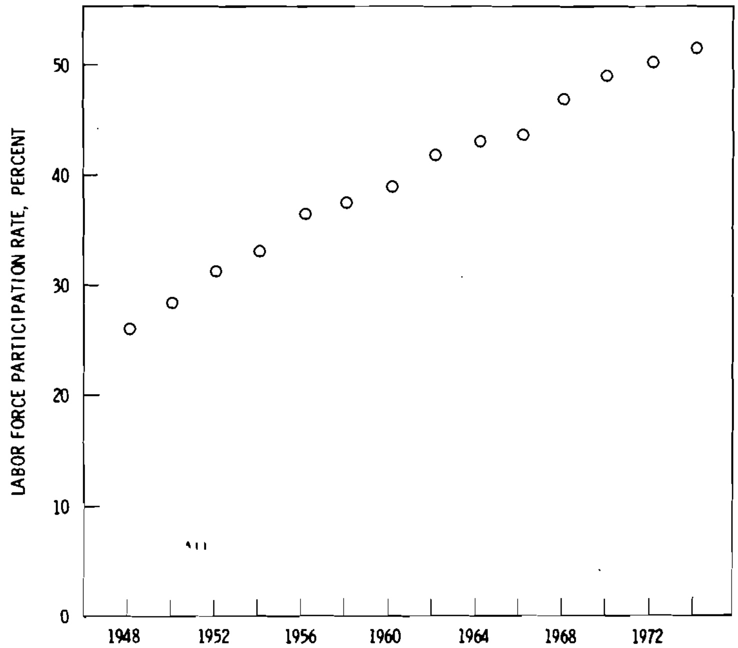


FIGURE 4. National Labor Force Participation Rate for Wives with School-Age Children. Source: Wall Street Journal 1976 (Reference 5)

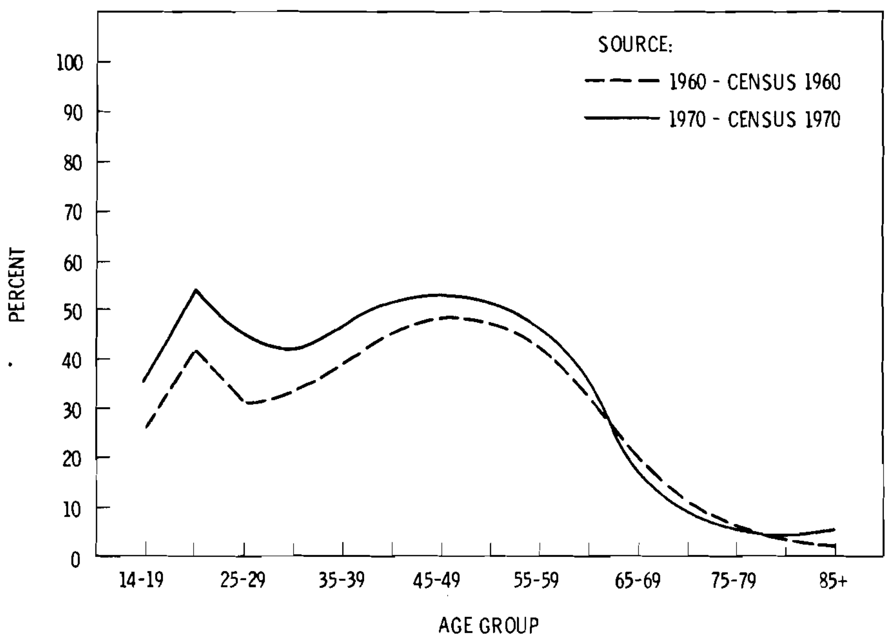


FIGURE 5. Washington 1960 and 1970 Female Labor Force Participation

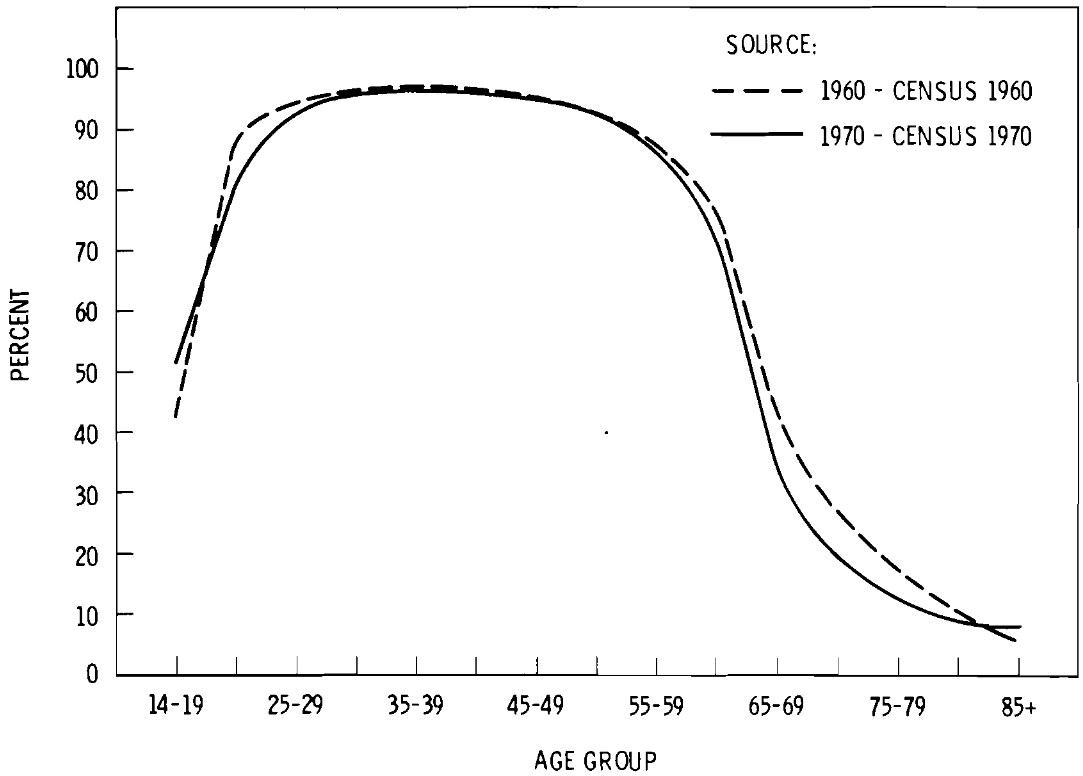


FIGURE 6. Washington 1960 and 1970 Male Labor Force Participation

TABLE 4. Employed Civilian Labor Force

State	1960	1970	Percent Change 1960-1970
Alaska	58,243	90,723	55.7
Idaho	232,858	262,277	12.6
Montana	236,562	248,342	4.9
Oregon	638,824	788,475	23.4
Washington	1,001,909	1,250,270	24.7
Wyoming	120,812	125,558	3.9
Total	2,289,208	2,765,645	20.8

Source: Bureau of the Census, 1960 and 1970 (References 6 and 7)

The data shown in Table 4 do not reflect changes in the states' economic activity from 1970 through 1975. Energy development in Montana, Wyoming and Alaska increased employment opportunities in these states, while Washington suffered a reduction in employment opportunities in the aerospace industry beginning in 1969.

DESCRIPTION OF DEMOGRAPHIC SECTOR

The demographic sector of the dynamics simulation model simulates the interactions among the population, birth rate, death rate, net migration rate, and jobs available in the Region from 1960 through 2020. These elements and some of their interactions are shown in Figure 7. Births, deaths, migration, and labor force participation are strongly influenced by the age structure of the population. For this reason the population is disaggregated so that age-specific birth rates and death rates, age-specific propensity to migrate, and age-specific labor force participation rates can be employed. There are six age classifications used: 0 to 17, 18 to 24, 25 to 29, 30 to 44, 45 to 64, and 65 and over. The rationale for selecting these classifications is based on arguments similar to those presented in the final report on "A Dynamic Model of the Economy of the Susquehanna River Basin," included as Appendix B.(8)

The population is also disaggregated by household size to allow the effects of changing family size on energy use to be evaluated. There are six household size classifications: single, married without children, and married with one, two, three, or four or more children. As shown in Figure 7 this categorization scheme can be viewed as a two-dimensional array, the axes being age and household size.

As shown by the three arrows pointing toward the population array, change in the population over time is determined by three factors: the number of births and the number of deaths, which combine to give the natural increase, and the net migration. The total number of births is computed by multiplying the age-specific birth rates by the number of women in each age group and summing the births from all age groups. Similarly, the total number of deaths is computed by multiplying the age-specific death rates by the number of people in each age group and summing.

Determining the net migration is a more complex procedure. The research literature dealing with determinants of migration is quite extensive.(9) Factors that have influenced migration include job opportunities, perceived job opportunities, wages, age, educational achievement, race, and climate. Also, factors that influence in-migration may be different from those determining out-migration:

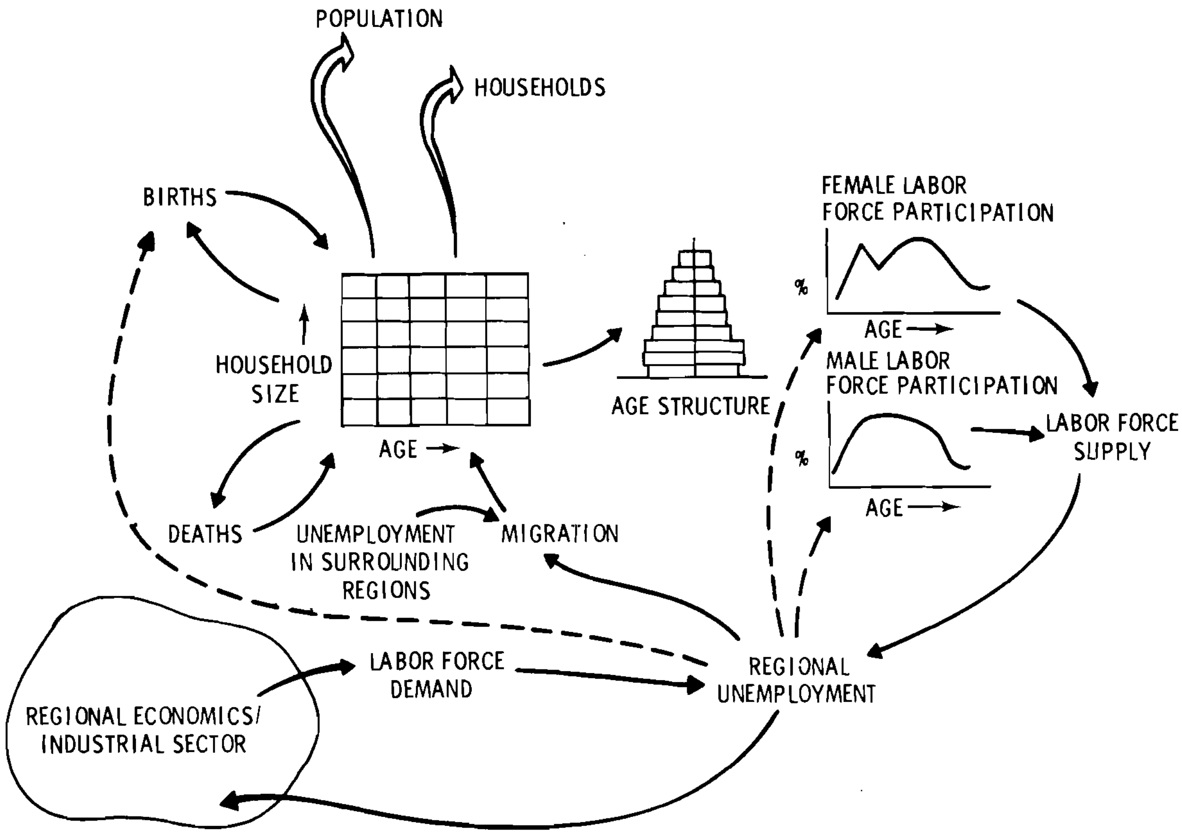


FIGURE 7. Interactions Within the Demographic Sector

"A finding common to a number of gross migration studies is that income (and job) opportunities provide a better explanation of in-migration than they do of out-migration. H. S. Perloff argues that localities with attractive economic conditions can draw sizeable numbers of migrants from other localities, though only small numbers may come from any single locality.[a] On the other hand, what is important in determining out-migration from a locality suffering from economic distress is the percentage of the labor force that is willing to leave in order to search for opportunities elsewhere. This percentage, argues Perloff, is sensitive to the personal characteristics of the residents of the locality, such as their age and their level of education."[9]

(a) H. S. Perloff, E. S. Dunn, Jr., E. E. Lampard and R. F. Muth, Regions, Resources, and Economic Growth. Baltimore: Johns Hopkins Press, 177, 1960.

Before the final demographic sector of the model can be implemented, the significant causes of both in- and out-migration in the Pacific Northwest must be determined and included either implicitly or explicitly. At the present time a simple representation of the determinants of migration is used, namely, the relative job opportunities in the Region compared to employment opportunities in the surrounding Regions. The relative employment opportunities are used to determine both in- and out-migration and, as a result, both in- and out-migration are combined and net regional migration is used.

Defining migration rates as a function of employment opportunities is the most common approach used in regional simulation models.[8, 10,11] To determine the regional employment opportunities the demand and supply of laborers in the Region must be known. The regional labor force supply is computed by multiplying the male and female age-specific labor force participation rates by the number of males and females in each age group in the labor force. Information about the regional labor force demand is provided by the economics/industrial sector of the model. Comparing this information with the employment opportunities in the surrounding regions indicates the relative regional employment opportunities and, in turn, the net regional migration.

The dashed lines in Figure 7 indicate three additional feedback links that have been shown to exist in other demographic modeling efforts.[8] These include the effect of unemployment or economic factors on the birth rate and the effect of unemployment on labor force participation. A summary of the reasons why the link between labor force participation and unemployment was incorporated into the Susquehanna River Basin model states:

> "During Phase III a feedback connection was introduced between employment conditions and labor-force-participation rates. The existence of such a relationship is supported by at least three different and independent empirical studies. A test of the new formulation shows that it helps to explain a considerable amount of the variation in participation rates among the Susquehanna subregions. There is furthermore, from a comparison of the Susquehanna findings with those of the other studies, some evidence that the labor-force-participation rates respond more dramatically to employment conditions in local economies than for the nation as a whole."[8, p. G-13]

The birth rates change linearly with the smoothed local unemployment rate in the Susquehanna River Basin model; the higher the unemployment rate, the lower the birth rate. The relationship between birth rates and the unemployment rate for the 20 through 24 year age group for the Susquehanna River Basin Model is shown in Figure 8.

No effort has yet been made to incorporate these relationships between unemployment and the birth rate and unemployment and labor force participation into the model. It is not clear that the effort required to verify and parameterize them would be justified considering the overall purpose of the analysis.

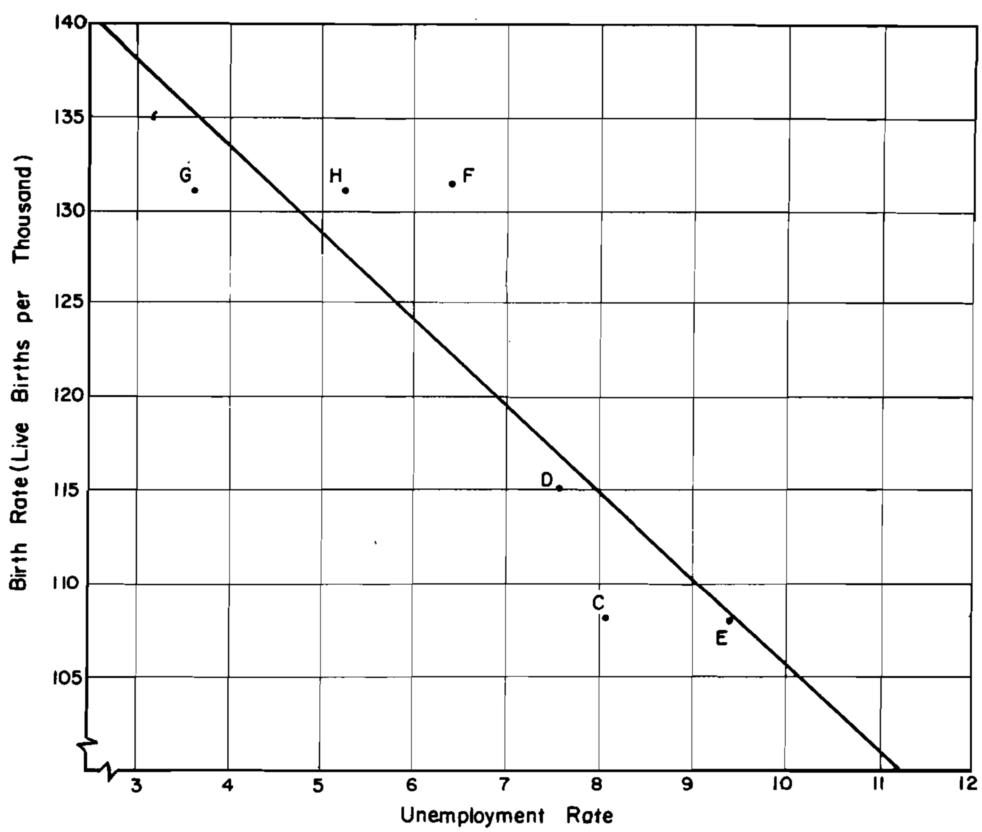


FIGURE 8. Birth Rate Versus Unemployment Rate for 20 to 24 Year Age Group
Source: H. R. Hamilton, et al., 1966 (Reference 8)

MODEL EQUATIONS

As mentioned in the previous section the population aged 18 and over is disaggregated into five age classifications and six household size groups. The population aged 0 through 17 is categorized in a single group reflecting the assumption that a negligibly small percentage of the people in this age bracket are married or have children. These classifications are shown in Figure 9.

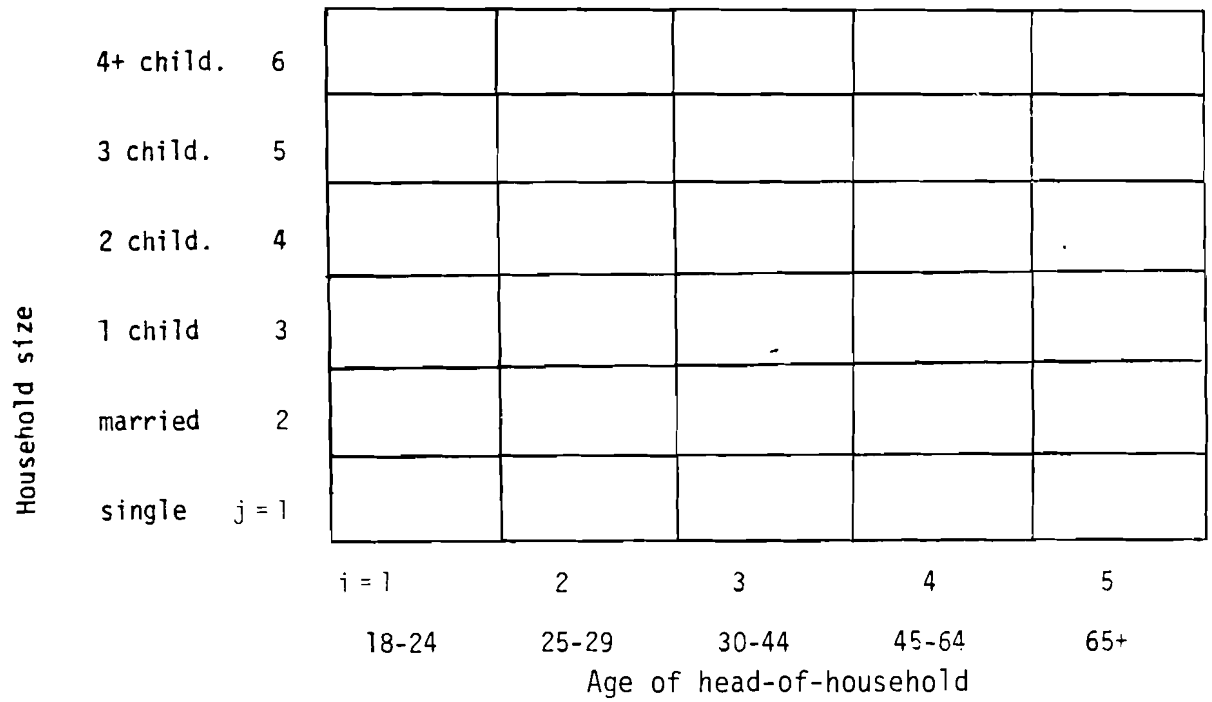


FIGURE 9. Age-Household Size Array

As shown, the age of the household heads is classified along the horizontal axis ($i = 1$ to 5) and the size of the household is classified along the vertical axis ($j = 1$ to 6). It is assumed that each married household either with or without children consists of two people of the same age.

In general there are eight mechanisms or flows by which households move within this classification scheme. Aging, births, deaths, youths maturing and forming their own households, and migration all combine to change the characteristics of a regional population over time. These flows are shown in Figure 10.

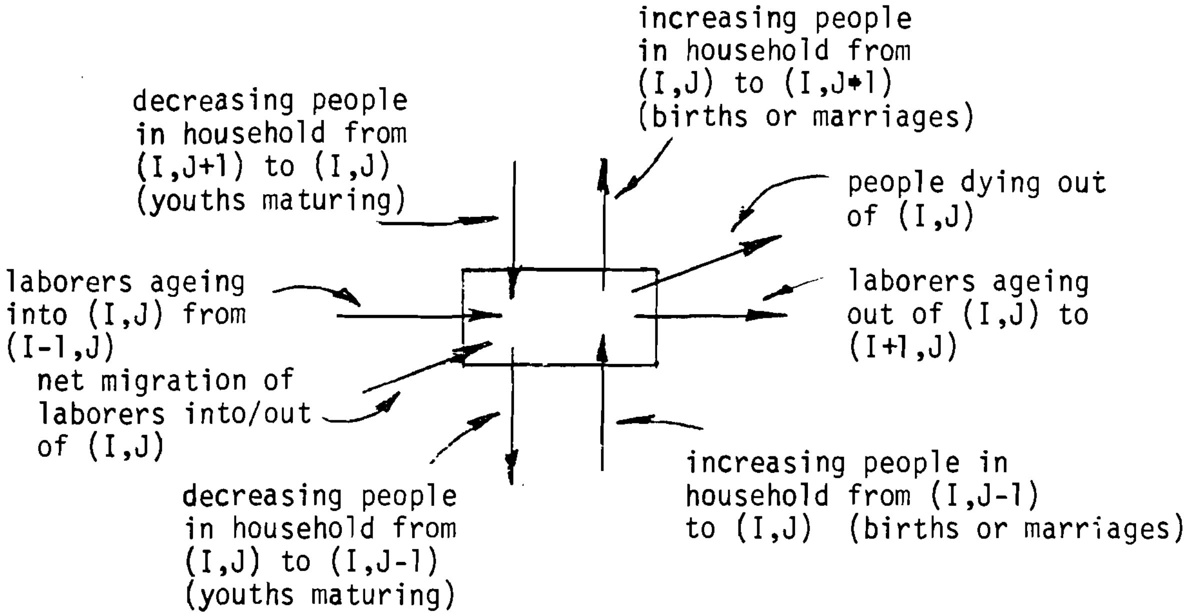


FIGURE 10. Rates Regulating the Movement of People Within the Age-Household Array

The number of people leaving a classification each year due to aging is computed by dividing the total households in each classification by the number of years in that classification. For example, the people aging out of a classification in the 25 to 29 age group will be the number of households in that category divided by five, the number of years they spend in that category. In general,

$$DLHAR_{ij} = DLHAM_i * DLH_{ij}$$

where

$DLHAR_{ij}$ = household aging rate; households aging out of category (ij)

$DLHAM_i$ = household aging multiplier; 1/duration of Ith age classification

DLH_{ij} = households; number of households in category (ij)

The number of births in any age category is computed by multiplying the applicable birth rate by the number of women in that category. It is assumed that there are an equal number of males and females in all categories, i.e., the sex ratio of the population is equal to 100. The birth rate is assumed to be a function of not only the age of the mother but also is a function of how many children the mother already has.

A special case exists for the movement of households from the j = 1 (single) grouping to the j = 2 (married without children) grouping. This movement is caused not by births but by marriages. As a result the multiplier used to compute the number of households making this transition represents the probability that an individual in a specific age classification will get married. By varying this parameter the effects of changing marriage ages on the population can be evaluated. The movement of households due to births or marriages can be represented in equation form by:

$$DLHMBR_{ij} = DLHMBM_{ij} * DLH_{ij}$$

where

$DLHMBR_{ij}$ = household marriage/birth rate; number of births or marriages in each grouping

$DLHMBM_{ij}$ = household marriage/birth multiplier; probability of marriages for j = 1, probability of births for j = 2 to 6

At present the probabilities of births, or more simply the birth rates, are exogeneous to the model and remain constant for all time periods. Since there has been a significant drop in the birth rates in the United States and the Pacific Northwest during the past 10 years, future work should include making the birth rate variable either as a function of time or as a function of socioeconomic variables.

The deaths are calculated in a similar manner: the deaths in each cell being the number of households in the cell multiplied by probability of death in that age group.

$$DLHDR_{ij} = DLHDM_{i} * DLH_{ij}$$

where

$DLHDR_{ij}$ = household death rate; number of people dying in grouping (ij)

$DLHDM_{i}$ = household death multiplier; probability of death for age (i)

The age-specific death rates are currently set exogeneously to the model and are constant. Little accuracy would be gained by making the death rates variable since death rates have remained relatively constant during recent years.

The movement of households from a j to a j-1 grouping is due to the maturation of youths, i.e., youths reaching 18 years of age. Assuming a constant age distribution of youths in all classifications, the number of households making the transition from a j to a j-1 grouping will be the number of people in that grouping divided by 18. In equation form:

$$DLHMR_{ij} = DLCMRM_{ij} * DLH_{ij}$$

where

$DLHMR_{ij}$ = household maturation rate; number of households moving from j to j-1

$DLCMRM_{ij}$ = child maturation rate multiplier; 1/18

It is important to have a clear definition of the relationships among the population, the labor force, the labor force participation rate, employed persons, and the unemployment rate to understand the equations used to determine migration. Figure 11 graphically defines these terms and their relationships.

The total labor force is compiled by adding the youths aged 14 through 17 in the labor force to the adults in the labor force. Again, the total population is assumed to be half female and half male.

$$DTL = DC*DCLFD*DCLFPR + \sum_{i=1}^{5} \sum_{j=1}^{6} (DLFLP_i*0.5*DLH_{ij} + DLMLP_i*0.5*DLH_{ij})$$

where

DTL = Total labor force

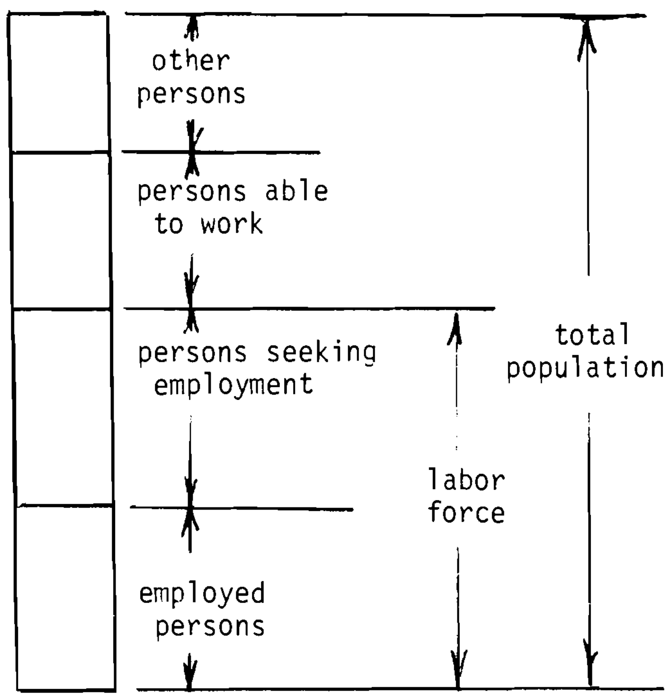
DC = Total youths (ages 1 through 17)

DCLFD = Youth labor force duration; all persons 14 and over are defined as being able to work, = (18-14)/18

DCLFPR = Youth labor force participation, percent

$DLFLP_i$ = Female labor force participation in age classification (i)

$DLMLP_i$ = Male labor force participation in age classification (i)



Labor Force participation Rate = Labor Force / Total Population

Unemployment Rate = (Labor Force-Jobs) / Labor Force

FIGURE 11. Terms Used to Define Composition of Population

As shown earlier in Figure 6, the age-specific male labor force participation rates have been relatively constant since 1960 in the Pacific Northwest and are constant in the model. In contrast, female labor force participation rates have increased in recent years and changed as a function of time. The female labor force participation rates for various ages in Washington State for 1960 and 1970 were shown in Figure 5.

To compute the net migration into or out of a classification, the total net migration is first found and then apportioned among the various groupings. The total migration is calculated as follows:

DLTMR = [JOBS * (1.0 + SRUNE) - DTL]/MDT

where

DLTMR = total net migration rate
JOBS = total jobs available in the region
SRUNE = unemployment rate in the surrounding regions
DTL = total laborers in the region
MDT = migration delay time

Notice that the net migration rate will be positive (indicating net in-migration) if the regional unemployment rate is lower than the unemployment in the surrounding regions and negative (indicating net out-migration) if the regional unemployment rate is higher than the unemployment in the surrounding regions. The net migration rate will be zero if the two unemployment rates are the same. The net migration for each grouping is then calculated using the total net migration rate. As mentioned earlier the propensity to migrate is dependent on age, people aged 18 through 30 being more likely to migrate than the older ages. This fact is incorporated into the model by a normalized "net migration age factor" which is higher for the younger age groups than for the older classifications. It is assumed that people migrating all have the same household size distribution as the existing population within any age category.

$$DLHNMR_{ij} = DLTMR * DLNMAF_i * (DLH_{ij}/DLHAT_j)$$

where

$DLHNMR_{ij}$ = household net migration rate into group (ij)

$DLNMAF_i$ = net migration age factor

$DLHAT_i$ = total households in age classification (i)

The youths aged 0 through 17 are assumed to migrate with their associated households.

MODEL OUTPUT

As explained in the introduction the demographic sector of the model is in its preliminary stage of development. As a result, demographic sector output shown in this section simply indicates the type of information that will be provided rather than projections of actual behavior. A report such as the one shown in Figure 12 is generated every 5 years. The 5-year reporting interval was arbitrarily selected since the information provided is updated and available every quarter.

The three components of change of the population--births, deaths and net migration--for the previous 5 years are listed across the top of Figure 12. The percent change in population over this period as well as the birth and death rates per 1000 people are also computed. The age distribution for the population is given in the lower right hand portion of the report. Several statistics about the population are listed along the lower left. The information presented here includes the number of people in the labor force, the unemployment rate, and the number of households.

The behavior of some of the same variables is shown as a function of time in Figure 13. The output shown in Figure 13 was generated by exogeneously setting the number of jobs available in the Region so that the population would match the average projection given in Figure 2. The labor force to job ratio remains constant throughout the run since the unemployment in the surrounding region is assumed to be constant and the unemployment rate in the Region seeks to match the unemployment in the surrounding region. Of course, the relationship between these parameters will be variable when the demographics sector is integrated with other sectors of the model.

DEMOGRAPHIC SECTOR
SUMMARY FOR 1970

(FIGURES IN THOUSANDS EXCEPT WHERE NOTED-*)

POPULATION	POPULATION CHANGE NUMBER	POPULATION CHANGE PERCENT*	-------COMPONENTS OF CHANGE FROM PREVIOUS PERIOD------- BIRTHS NUMBER	BIRTHS RATE*	DEATHS NUMBER	DEATHS RATE*	NATURAL INCREASE	NET MIGRATION NUMBER	NET MIGRATION RATE*
7424.6	465.9	6.7	766.6	.1	226.0	.0	540.6	-74.7	-.0

LABOR FORCE	3027.8
JOBS AVAILABLE IN REGION	2830.0
PERCENT UNEMPLOYED*	.065
TOTAL HOUSEHOLDS	2438.9
RURAL HOUSEHOLDS	1136.5
URBAN SINGLE FAMILY HOUSEHOLDS	651.2
URBAN MULTIPLE FAMILY HOUSEHOLDS	651.2
PEOPLE PER HOUSEHOLD*	3.04

AGE DISTRIBUTION

		CHANGE FROM -PREVIOUS PERIOD NUMBER	PERCENT*
0-17	2546.8	62.5	2.5
18-24	951.2	129.1	15.7
25-29	622.9	107.2	20.8
30-44	1390.6	108.9	8.5
45-64	1317.2	18.5	1.4
65+	595.9	39.8	7.2

NOTE: RATES ARE PER 1000 POPULATION

FIGURE 12. Five-Year Summary Output

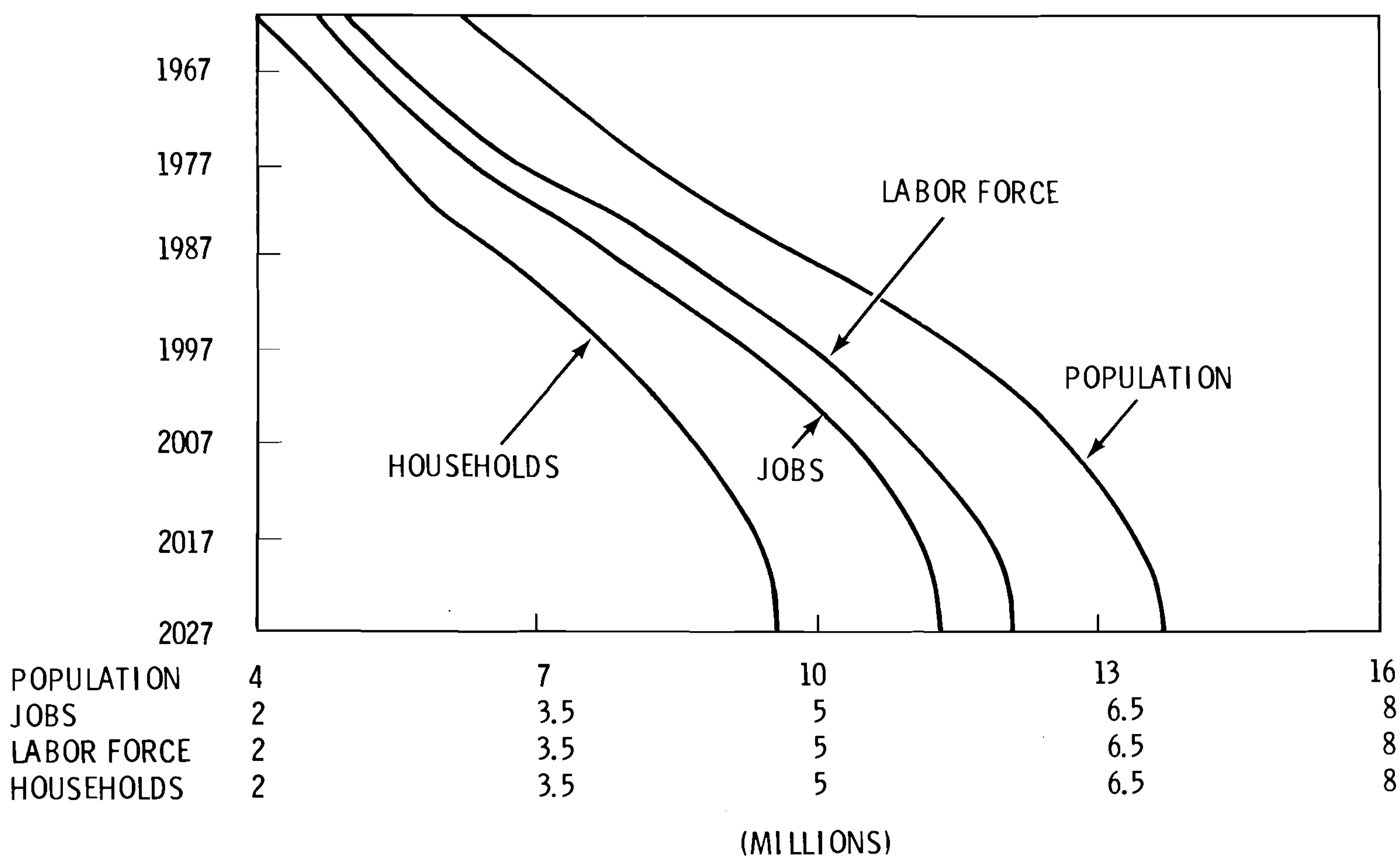


FIGURE 13. Model Output 1960 Through 2020

FURTHER WORK

Further work with the demographic sector will involve three basic tasks: (1) improvement of the existing structure, (2) integration and adaption with the energy supply and demand and economic activity sectors, and (3) collecting and verifying the additional data required. Since the data collection task will largely be determined by the course of the integration and adaption task, data collection is implicit in the following discussion. The list of possible modifications to the demographic sector of the model include:

1. Making both birth rates and labor force participation functions of regional unemployment. (These modifications were discussed earlier in the report.)

2. Reducing the number of household size classifications from six to two or three. The primary reason for having six household size classifications was to allow the effects of household size on energy demand to be evaluated. Existing energy demand models reviewed for adaption into the model framework do not require such detailed household size information. Unless further research shows a requirement for such information the number of household size classifications should be reduced.

3. Disaggregating the demographic sector of the model to include state subregions. There is a tradeoff between greater disaggregation to achieve realism and credibility and the associated penalties this brings with respect to additional data requirements, complexity, and increased computer costs. After considering the above tradeoffs it was decided that the initial model would be aggregated to combine all six states into a single region. The existing demographic sector of the model reflects this decision.

   Over the course of the past year, two underlying reasons in favor of greater disaggregation have developed. One reason stems from the fact that the most applicable industrial energy demand equations allocate total U.S. industrial energy use among the various states partially as a function of individual state population.[12] This formulation requires that the population of individual states be known.

The other reason for disaggregating the model reflects the desire of state decision makers to explicitly see the effects of various national and regional policies on their individual state. While statewide effects could be implicitly assumed from a more aggregated model, the model and associated analysis gains in credibility and realism if individual states are represented.

There seems to be little need to disaggregate the regional model to the substate level.

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APPENDIX A

PACIFIC NORTHWEST REGION POPULATION DATA

APPENDIX A

PACIFIC NORTHWEST REGION POPULATION DATA

Appendix A is a compilation of population data for the six states which are defined as composing the Pacific Northwest Region in this study.

Tables A1 and A2 list the actual 1960 and 1970 population of the various states according to the U.S. Bureau of the Census. Table A3 gives the estimated[a] 1975 population of the states issued by the Bureau of the Census in November 1975.

Tables A4 through A9 list the most recent state population projections for the six states prepared by agencies in each of the respective states. Table A10 presents projections of population for Idaho, Oregon and Washington prepared by the Bonneville Power Administration (BPA).[13]

The data obtained from the individual states and the BPA along with the Bureau of Census data for 1960, 1970 and 1975 are plotted for each state in Figures A1 through A6. For each projection the data were extrapolated to the year 2020. In each case the extrapolation was made assuming population growth will level off.

The population forecast shown in Figure A7 (which is the same as Figure 2) was derived from Figures A1 through A6.

The upper dashed line in Figure A7 was obtained by summing the highest population projection/extrapolation from each of the states for a given year. The lower dashed line was obtained in a similar manner except using the lowest

(a) It is useful to note the differences in the definition of estimate, projection, forecast, and extrapolation as used in this report. A forecast is any attempt to foretell the population. Estimates, projections and extrapolations are all different methods of making a forecast. An estimate is a short term forecast (1-5 years) which is usually developed using regression techniques on past data as well as assumptions regarding fertility, mortality and migration. Projections are longer term forecasts (5-20 years) which are prepared using fertility, mortality and migration assumptions but not regression techniques. Extrapolations are forecasts prepared using graphical trend extrapolation. They are used in this report to extend the time horizon of existing projections.

projection/extrapolation. In the cases of Alaska, Montana and Wyoming, where only a single forecast was obtained, the same forecast is summed into both the high and low curves. The solid curve represents the arithmetic average of the two dashed curves.

Tables A11 through A19 list the low, high and average population projections and extrapolations which were used in Figure A7.

TABLE A1. Actual 1960 Populations for Pacific Northwest States

Source: Census 1960 (Reference 6)

Alaska	226,167
Idaho	667,191
Montana	674,767
Oregon	1,768,675
Washington	2,853,214
Wyoming	330,066
Total	6,520,080

TABLE A2. Actual 1970 Populations for Pacific Northwest States

Source: Census 1970 (Reference 7)

Alaska	300,382
Idaho	712,567
Montana	694,409
Oregon	2,091,385
Washington	3,409,169
Wyoming	332,416
Total	7,540,328

TABLE A3. Estimated 1975 Populations for Pacific Northwest States

Source: Census 1975 (Reference 1)

Alaska	352,000
Idaho	820,000
Montana	748,000
Oregon	2,288,000
Washington	3,544,000
Wyoming	374,000
Total	8,126,000

TABLE A4. Projected Alaska Population 1980-1983

Source: Alaska 1975 (Reference 14)

Year	
1980	471,300
1983	542,600

TABLE A5. Projected Idaho Population 1980-2000

Source: Idaho 1976 (Reference 15)

Year	
1980	970,700
1985	1,119,320
1990	1,256,200
1995	1,362,780
2000	1,467,270

TABLE A6. Projected Montana Population 1970-1990

Source: Montana 1975 (Reference 16)

Year	
1980	816,060
1985	893,624
1990	970,770

TABLE A7. Projected Washington Population 1980-2000

Source: Washington 1972 (Reference 17)

Year	
1980	3,672,100
1985	3,915,100
1990	4,168,600
1995	4,372,800
2000	4,571,900

TABLE A8. Projected Wyoming Population 1980-2000

Source: Wyoming 1976 (Reference 18)

Year	
1980	443,411
1985	474,694
1986	472,045

TABLE A9. Projected Oregon Population 1980-2000

Source: Oregon 1975
(Reference 19)

Year	Migration Assumption: Low	Medium	High
1980	2,496,982	2,517,372	2,543,523
1985	2,679,602	2,738,583	2,822,586
1990	2,835,968	2,951,277	3,126,367
1995	2,952,949	3,141,962	3,442,042
2000	3,020,208	3,301,361	3,761,465

TABLE A10. Projected Idaho, Oregon, and Washington Populations 1980-1995

Source: BPA 1976
(Reference 13)

Year	Idaho	Oregon	Washington
1980	911,900	2,465,700	3,776,500
1985	1,003,000	2,633,500	4,054,800
1990	1,088,800	2,795,900	4,333,700
1995	1,163,200	2,942,500	4,583,200

The superscript numbers in the following tables refer to these sources:

1. Alaska 1975 3. Montana 1975 5. Washington 1972 7. BPA 1976
2. Idaho 1976 4. Oregon 1975 6. Wyoming 1976 8. Extrapolated

TABLE A11. Projected Low, High, and Average 1980 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	471,300[1]	471,300[1]	471,300
Idaho	911,900[7]	970,700[2]	941,300
Montana	816,060[3]	816,060[3]	816,060
Oregon	2,469,500[7]	2,543,523[4]	2,506,511
Washington	3,672,100[5]	3,776,500[7]	3,724,300
Wyoming	443,411[6]	443,411[6]	443,411[6]
Total	8,784,271	9,021,494	8,902,882

TABLE A12. Projected and Extrapolated Low, High, and Average 1985 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	580,000[8]	580,000[8]	580,000
Idaho	1,003,000[7]	1,119,320[2]	1,061,160
Montana	893,624[3]	893,624[3]	893,624
Oregon	2,636,700[7]	2,822,586[4]	2,729,643
Washington	3,915,100[5]	4,054,800[7]	3,984,950
Wyoming	474,694[6]	474,694[6]	474,694[6]
Total	9,503,118	9,945,024	9,724,071

TABLE A13. Projected and Extrapolated Low, High, and Average 1990 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	670,000[8]	670,000[8]	670,000
Idaho	1,088,800[7]	1,256,200[2]	1,172,500
Montana	970,770[3]	970,770[3]	970,770
Oregon	2,797,800[7]	3,126,367[4]	2,962,083
Washington	4,168,600[5]	4,333,700[7]	4,251,150
Wyoming	472,045[8]	472,045[8]	472,045[8]
Total	10,168,015	10,829,082	10,498,548

TABLE A14. Projected and Extrapolated Low, High, and Average 1995 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	750,000[8]	750,000[8]	750,000
Idaho	1,163,300[7]	1,362,780[2]	1,263,040
Montana	1,025,000[8]	1,025,000[8]	1,025,000
Oregon	2,944,400[7]	3,442,042[4]	3,193,221
Washington	4,372,800[5]	4,583,200[7]	4,478,000
Wyoming	472,000[8]	472,000[8]	472,000[8]
Total	10,727,500	11,635,022	11,181,261

TABLE A15. Projected and Extrapolated Low, High, and Average 2000 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	800,000[8]	800,000[8]	800,000
Idaho	1,230,000[8]	1,467,270[2]	1,348,635
Montana	1,150,000[8]	1,150,000[8]	1,150,000
Oregon	3,020,208[4]	3,761,465[4]	3,390,836
Washington	4,571,900[5]	4,800,000[8]	4,685,950
Wyoming	472,000[8]	472,000[8]	472,000[8]
Total	11,244,108	12,450,735	11,847,421

TABLE A16. Extrapolated Low, High, and Average 2005 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	840,000	840,000	840,000
Idaho	1,280,000	1,540,000	1,410,000
Montana	1,260,000	1,260,000	1,260,000
Oregon	3,010,000	4,070,000	3,540,000
Washington	4,750,000	4,970,000	4,860,000
Wyoming	472,000	472,000	472,000
Total	11,612,000	13,152,000	12,382,000

TABLE A17. Extrapolated Low, High, and Average 2010 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	870,000	870,000	870,000
Idaho	1,320,000	1,600,000	1,460,000
Montana	1,350,000	1,350,000	1,350,000
Oregon	3,050,000	4,350,000	3,700,000
Washington	4,900,000	5,150,000	5,025,000
Wyoming	472,000	472,000	472,000
Total	11,962,000	13,792,000	12,877,000

TABLE A18. Extrapolated Low, High, and Average 2015 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	890,000	890,000	890,000
Idaho	1,360,000	1,650,000	1,505,000
Montana	1,420,000	1,420,000	1,420,000
Oregon	3,080,000	4,550,000	3,815,000
Washington	5,000,000	5,250,000	5,125,000
Wyoming	472,000	472,000	472,000
Total	12,222,000	14,232,000	13,227,000

TABLE A19. Extrapolated Low, High, and Average 2020 Populations for Pacific Northwest States

	Low	High	Average*
Alaska	900,000	900,000	900,000
Idaho	1,400,000	1,720,000	1,560,000
Montana	1,480,000	1,480,000	1,480,000
Oregon	3,100,000	4,750,000	3,925,000
Washington	5,050,000	5,360,000	5,205,000
Wyoming	472,000	472,000	472,000
Total	12,402,000	14,682,000	13,542,000

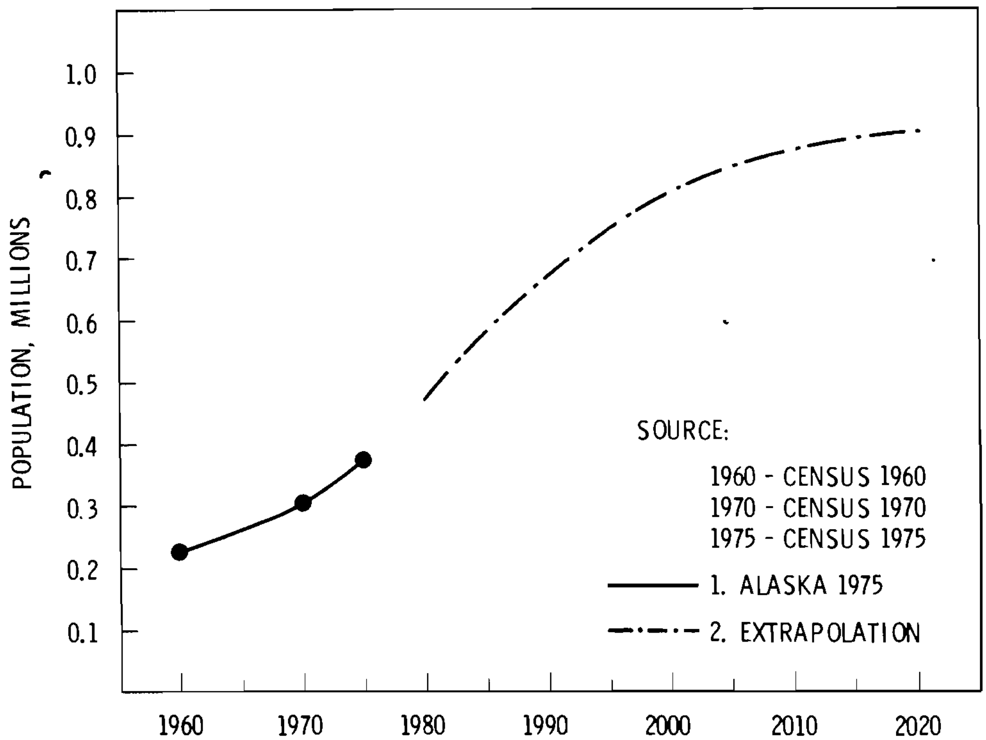

FIGURE A1. Population Forecast for Alaska

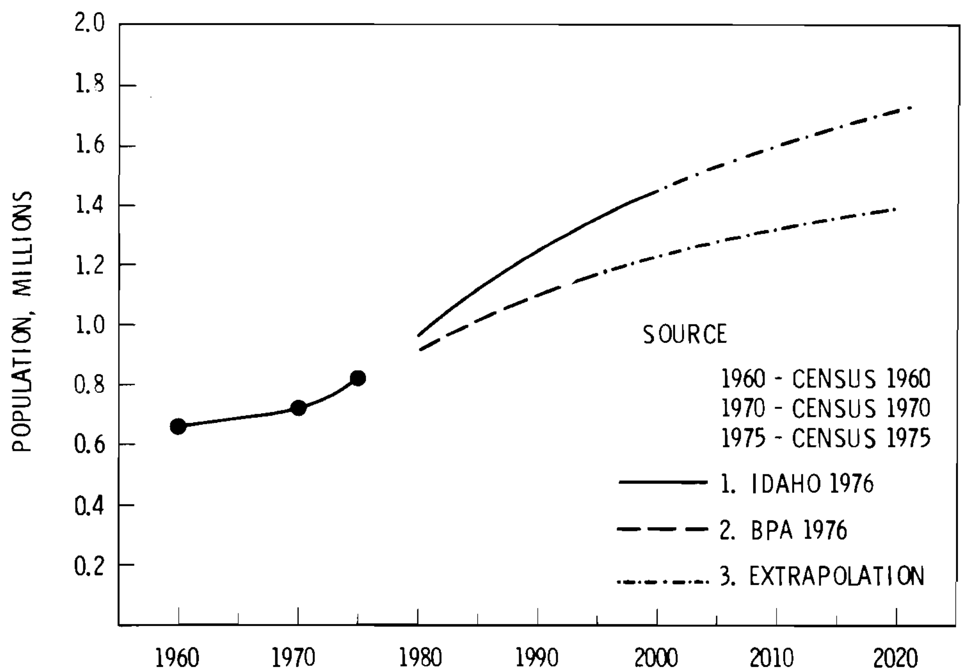

FIGURE A2. Population Forecast for Idaho

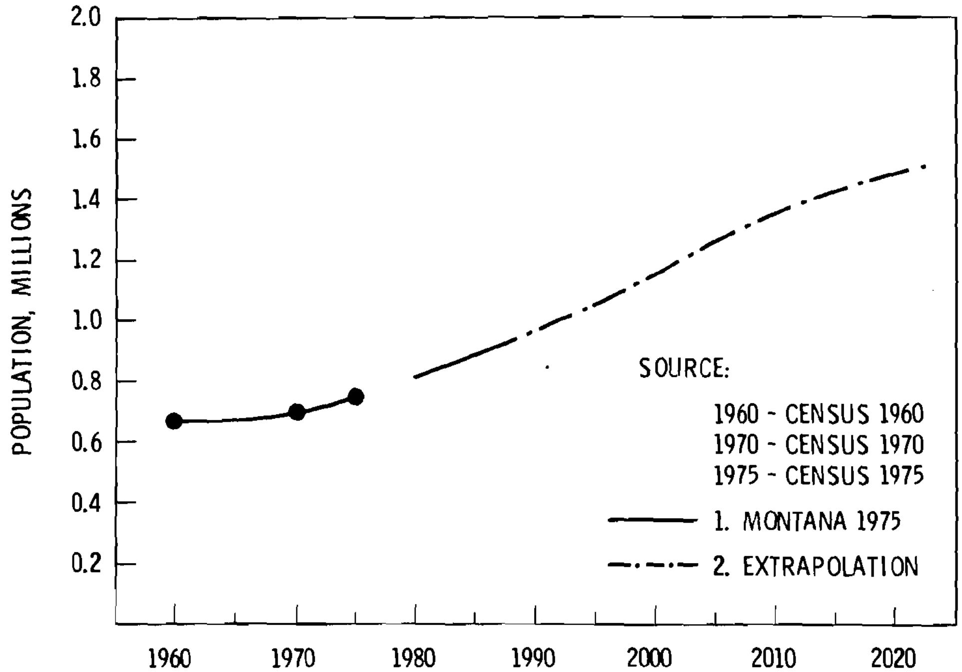

FIGURE A3. Population Forecast for Montana

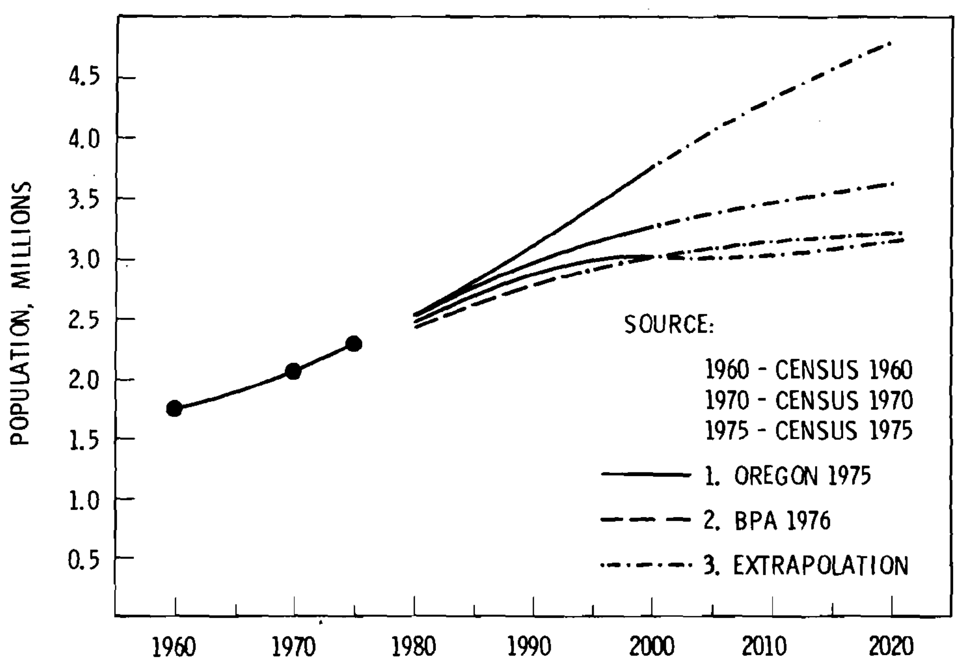

FIGURE A4. Population Forecast for Oregon

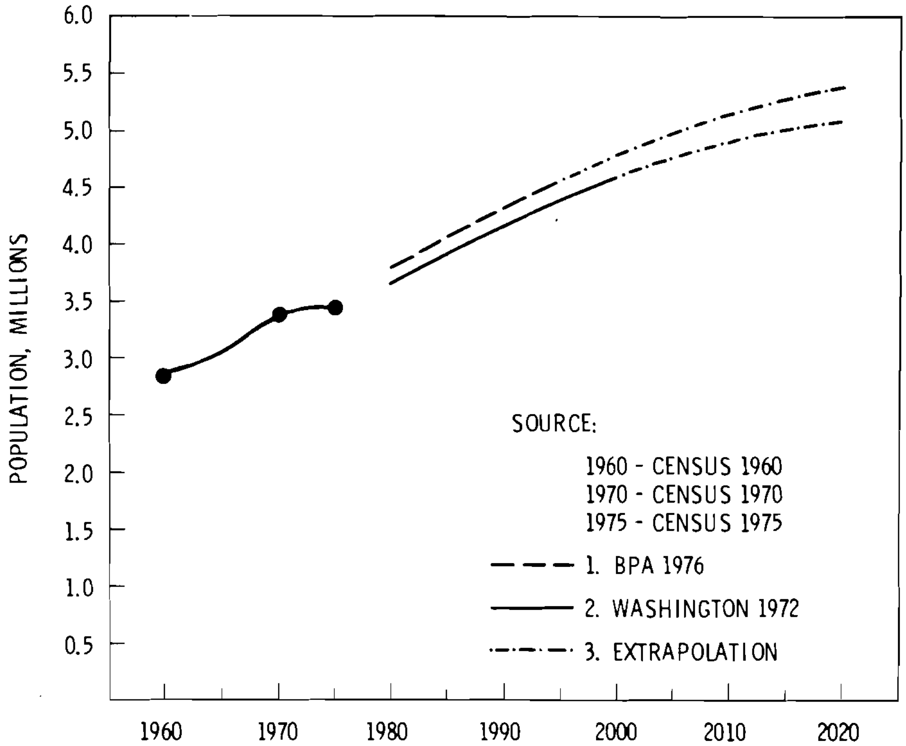

FIGURE A5. Population Forecast for Washington

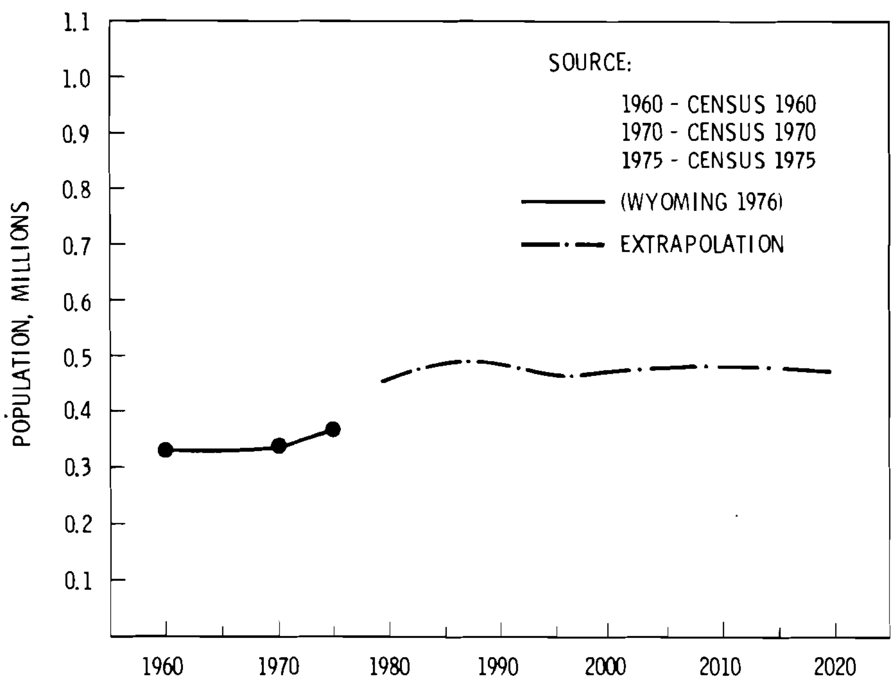

FIGURE A6. Population Forecast for Wyoming

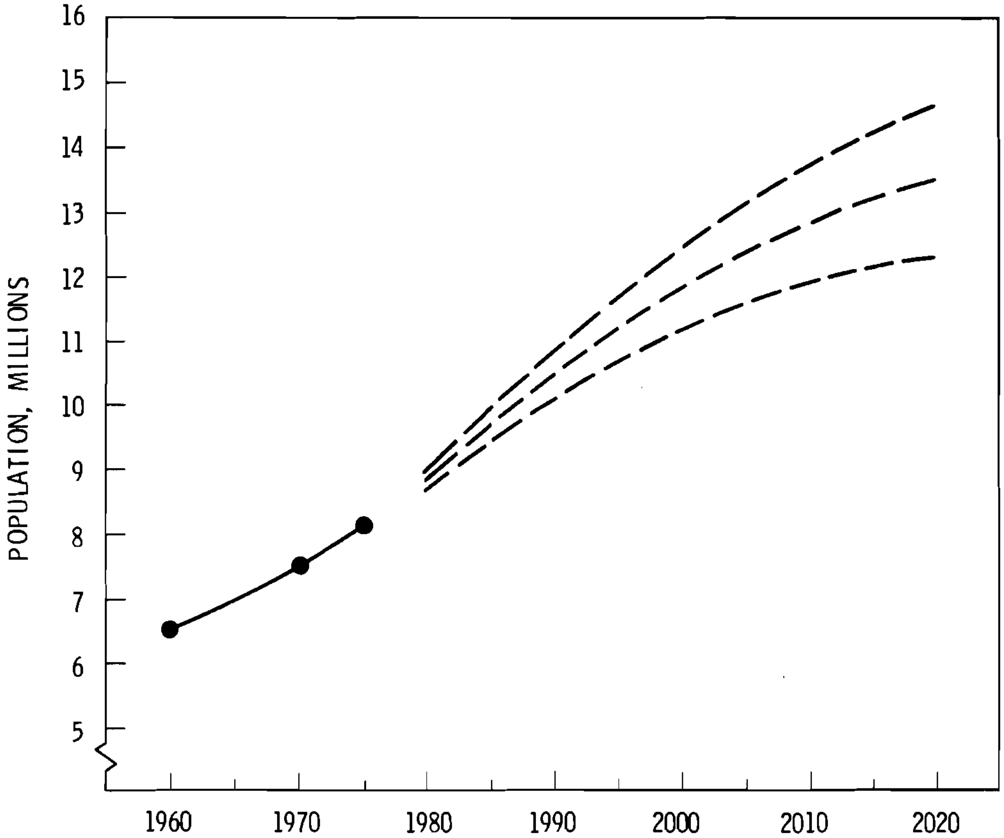

FIGURE A7. Derived Low, High, and Average Population Forecast for Pacific Northwest States

APPENDIX B

AGE GROUPING[a]

(a) Reprinted from: H. R. Hamilton, et al., A Dynamic Model of the Economy of the Susquehanna River Basin. A report to Susquehanna River Basin Utility Group by Battelle Memorial Institute, Columbus Laboratories, Columbus, OH, pp. D-2 to D-8, August 1, 1966.

APPENDIX B

AGE GROUPING

Once the decision is made to divide into age groups, there is the problem of how many and what groups to use. The problem is created in part because of practical difficulties caused by model size. Larger models naturally require longer computer running times and are to be avoided for this reason. Perhaps of a more serious nature is the fear that the computer capacity will be reached before a model is complete. In retrospect it appears that there may have been a degree of overconcern for these eventualities in this study since the demographic sector was formulated first and turned out to be very large in terms of numbers of equations. As a matter of fact, the other sectors required fewer equations than originally anticipated and the potential problem became somewhat of a straw man. It is of interest, nevertheless, to review the age-grouping procedures.

The number of age groups depends on two factors; first, the relative emphasis to be placed upon demography in the problem being studied, and second, the degree of homogeneity that is exhibited by various age classes with respect to variables such as fertility, death rates, migration, and labor-force participation. Ages with similar characteristics in relation to these variables can be grouped, since people of all ages in the group respond to the changing environment in a similar fashion. For example, children from 1 year of age through the early teens are a homogeneous group in many ways. Death rates are low, fertility is virtually nonexistent, they migrate with their parents, and there is virtually no labor-force participation. Other ages may be assembled into groups with similar characteristics, though few will exhibit as much homogeneity as do children. The main problems in grouping seem to be related to what might be called the transitional ages, those ages when individuals are apt to change their role in society. A good example is the late teens, when young people have the alternatives of continuing their education, participating in the labor force, and marrying. The characteristics of these ages change rapidly with age and require rather small age groupings of 5 years or less. Further, the choices those in the age group make with regard to entering the labor force, etc., are not static and often change in relation to expectations, a factor not nearly as important to the older age groups who, in fact, often have few real alternatives open to them.

Tables D-1, D-2, and D-3 present data that are relevant to an initial grouping of ages. Some of the more obvious groupings are indicated on the tables. The data are certainly suggestive of others. In deriving such age groups, two factors were considered: first, the percentage change in relevant variables between groups on which data were available, and, second, the importance of the absolute magnitudes of the variables themselves. For instance, if a rate doubles from one age category to the next, such a marked shift will be important unless the numbers themselves are so small as to be insignificant.

TABLE D-1. LIVE-BIRTH RATES

(Per 1000 female population per year)

Year	Age of Mother 10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
1940	0.7	54.1	135.6	122.8	83.4	46.3	15.6	1.9
1950	1.0	81.6	196.6	166.1	103.7	52.9	15.1	1.2
1960	0.8	89.1	258.1	197.4	112.7	56.2	15.5	0.9

Source: U. S. Bureau of the Census, Statistical Abstract of the United States: 1962, U. S. Department of Commerce, (Eighty-Third Edition) (1962), Table 54, p 55.

TABLE D-2. DEATH RATES

(Per 1000 population per year)

Age	1940	1950	1960
Under 1	54.9	33.0	27.0
1-4	2.9	1.4	1.1
5-14	1.0	0.6	0.5
15-24	2.0	1.3	1.1
25-34	3.1	1.8	1.5
35-44	5.2	3.6	3.0
45-54	10.6	8.5	7.6
55-64	22.2	19.0	17.4
65-74	48.4	41.0	38.2
75-84	112.0	93.3	87.5
85 and over	235.7	202.0	198.6

Source: U. S. Bureau of the Census, Statistical Abstract of the United States: 1963, U. S. Department of Commerce (Eighty-Fourth Edition) (1963), Table 67, p 62.

TABLE D-3. LABOR-FORCE-PARTICIPATION RATES

By Age and Sex

(Percent)

Age	1960	1975 (Est.)
Male		
14-17	34.4	32.1
18-19	73.1	70.0
20-24	88.9	85.7
25-54	95.0	95.0
55-64	85.2	80.8
65+	32.2	25.4
Female		
14-17	20.8	20.2
18-19	51.0	49.7
20-44 (except)	44.6	47.2
25-34	35.8	38.0
45-54	49.3	56.0
55-64	36.7	42.5
65+	10.5	10.5

Source: U. S. Bureau of the Census, Statistical Abstract of the U. S., 1963, U. S. Department of Commerce (Eighty-Fourth Edition) (1963), Table 288, p 220.

In relation to live-birth rates, three obvious groupings are apparent. Births in the group under 14 years of age are negligible, as they are among women over 45 years of age. Other groupings are not so obvious.

Death rates are seemingly related to three groups, under 1 (infant mortality), 1-44, and 45 and over. Some division of the over-45 group seems desirable but the breakdown is not obvious. The entire population can be broken into two groups (0-44, 45+), by subtracting infant deaths from live births, thus lowering the "effective" birth rate.

Labor-force-participation rates are another important consideration. Table D-3 illustrates three obvious breakouts: 14-17, 18-64, and 65+. This table also illustrates why, for the analysis of some problems, sex distinctions may be important – not only were male and female participation rates different in 1960, but their projected trends are different.

The migration characteristics of several potential age groups were also considered, and are shown in Table D-4. These data are not particularly suggestive of any clear-cut groups. However, it may be assumed that the majority of those under 17 will migrate with their parents.

Table D-5 shows the obvious groups suggested by the first four tables. Apparently, at least four age groups are needed. After further consideration, six age groups were selected. These were 0-13, 14-19, 20-24, 25-44, 45-64, and 65+. Table D-6 shows the number of people in each of these age groups by subregion in 1960.

The 0-13 group is quite homogeneous. Most of the few births falling in the 0-14 age category shown in Table D-1 are probably those of 14-year-olds. A finer breakout of migration data within the 7-17 category would probably show the 0-13 group as a good choice, particularly in light of the fact that this group surely migrates with its parents. With regard to deaths, the breakout is superfluous but not harmful. As far as labor-force participation, it is an obviously homogeneous group.

Groupings beyond the 0-13 category were not as clear cut. Birth-rate data suggested a break somewhere prior to age 20, as did labor force-participation data; 19 was selected for the break.

Migration data suggested the 20-24 age grouping, though surely not in a clear-cut fashion. Birth data also suggested this as a relevant age group, again not clearly, however. Nevertheless 20-24 was selected. The short age span of the 14-19 and 20-24 age groups reflects their transitional character.

No clear reason was apparent for not selecting the entire 25-44 age category as a useful grouping. Birth rates dictated that 44 be about the upper limit of this next group.* Also, death rates begin to increase at this point.

In a similar fashion, the 45-64 age group seemed viable. Labor-force participation dictates that those over 65 years of age be treated separately.

*Admittedly, birth rates are suggestive of groupings within the 25-44 span.

TABLE D-4. MIGRANTS BETWEEN STATES, BY AGE, MARCH 1959 – MARCH 1960

Age	Percent of Civilian Population That Moved Between States, March 1959-March 1960
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, p 15.

TABLE D-5. PRELIMINARY AGE GROUPINGS

Group	Births	Migration	Deaths	Labor-Force Participation	Final Selections
1	0-14	0-17	0-44	0-13	0-13
2	15-44	18+	45+	14-17	14-19
3	45+	--	--	18-64	19-24
4	--	--	--	65+	25-44
5	--	--	--	--	45-64
6	--	--	--	--	65+

TABLE D-6. TOTAL POPULATION BY AGE GROUP, SUSQUEHANNA RIVER BASIN, 1960

Subregion	Age, years						
	0-13	14-19	20-24	25-44	45-64	65+	Total
A	113,588	37,670	24,966	93,026	74,382	41,995	385,627
B	135,116	41,136	24,923	115,227	96,445	50,591	463,438
C	120,551	42,647	30,632	108,793	84,396	43,684	430,703
D	52,671	18,195	10,730	50,314	45,636	22,733	200,279
E	152,726	52,839	29,876	160,810	157,847	72,455	626,553
F	74,141	24,530	14,218	65,234	56,718	28,685	263,526
G	300,355	91,334	59,849	278,398	214,048	102,997	1,046,981
H	532,363	154,645	112,668	513,160	354,569	136,340	1,803,745
TOTAL	1,481,511	462,996	307,862	1,384,962	1,084,041	499,480	5,220,852

Sources: U. S. Bureau of the Census, U. S. Census of Population: 1960, General Population Characteristics, Maryland, U. S. Department of Commerce, Final Report PC(1)-22B (1961), Table 27, 22-58-22-64.

U. S. Bureau of the Census, U. S. Census of Population: 1960, General Population Characteristics, New York, U. S. Department of Commerce, Final Report PC(1)-34B (1961), Table 27, 35-155-34-173.

U. S. Bureau of the Census, U. S. Census of Population: 1960, General Population Characteristics, Pennsylvania, U. S. Department of Commerce, Final Report PC(1)-40B (1961), Table 27, 40-230-40-247.

A number of problems related to the set of age groups selected are readily apparent. The data used to derive them are also suggestive of other groupings and these may be just as valid. However, validity is a difficult concept to define in this situation, since not even 1-year breakouts will be absolutely perfect. Usefulness, is a better criterion. Since the above grouping was not altered during the Susquehanna program, it was obviously judged useful by the research team. This is not to say that the team would use exactly the same breakout again, but that the payoff from the changes thought useful was lower than might be derived from research devoted to other parts of the model. It is, after all, a sizable task to assemble the data and make parameter estimates for new age classes for eight subregions.

If one were highly interested in the population dynamics of a particular regional economy, a more detailed breakout of age groups might be of value in relation to two kinds of age categories. First, the transition groups such as the middle and late teens, as well as the younger segments of the 24-44 group, are prime targets for further disaggregation. Also, the groups with longer age spans such as the 25-44, 45-65, and possibly, the 0-13 groups may be somewhat too large, such that the effects of certain population dynamics will be masked. To illustrate, suppose a region experienced a 10-year period of heavy outmigration. This migration would affect the age groups differentially, the younger age groups feeling the impact to the greatest degree. Therefore, a trough in the age structure such as that shown in the left-hand graph in Figure D-3 would be created. A model with a very definitive age structure would move this trough of deleted ages through the population structure over time virtually intact, as shown by the solid line on the right-hand graph in Figure D-3. However, the model assumes that the distribution of ages within an age grouping is rectangular, that is, the number of people each year of age in the group is the same. Each year it then ages a definite fraction of the age group into the following age group; for instance, if the age span of the group is 20 years, 1/20th are aged. Understanding this mechanism makes the problem clear. As a trough reaches an age group, it "spreads out" over the age group immediately, also affecting those aged to the next older group immediately.

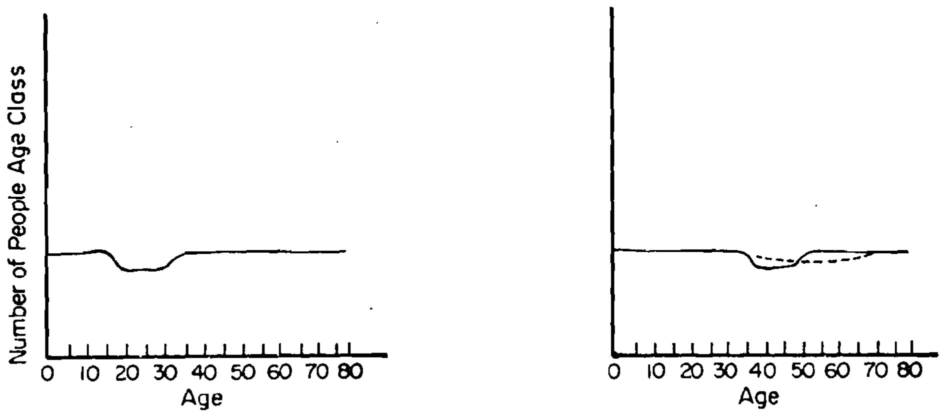

FIGURE D-3. THE MOVEMENT OF A TROUGH IN THE AGE STRUCTURE THROUGH THE POPULATION OVER TIME

Recognizing the problem caused by age groups covering a large number of years, a limited number of sensitivity experiments were performed to judge the severity of the difficulties created. The dynamic effects were much less than might be expected intuitively, and the problem was not judged of sufficient magnitude to warrant further effort in relation to the Susquehanna research.

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