MULTILEVEL COMPUTER MODEL OF WORLD DEVELOPMENT SYSTEM

User Oriented Descriptions

A SERIES: PART I. THE POPULATION MODEL

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FOREWORD

This paper is the first in a series of Working Papers on the "Multilevel Computer Model of World Development Systems." While the assumptions and the methodology of the various submodels pertaining to the above computer model are described in the IIASA Symposium Proceedings SP-74-1 to SP-74-6, this series aims at explaining the use of the models.

The series consists of seven papers, one for each submodel now available at IIASA. The descriptions relate to the state of the computer model in May, 1974. Since the research work under the leadership of M. Mesarovic and E. Pestel is still going on the model descriptions should not be looked upon as final. Further submodels will be documented as soon as they become available.

At present the various submodels are kept on a magnetic tape and partly on punched cards, and thus are easily accessible. I would like anybody who is interested in running a submodel from the M.P. Global Modelling Set to contact Günther Fischer (Ext. 411).

IMPLEMENTATION OF THE M.P. WORLD MODEL

In May 1974 a seminar was held by IIASA in Baden, at which the "Regionalized Multilevel World Modelling Project" headed by M. Mesarovic and E. Pestel was presented to scientists of various disciplines. In January 1975 the proceedings of this seminar were available at IIASA. In these reports (6 volumes; SP-74-1 to SP-74-6) the assumptions used within the models and in part the data are described.

We now have some of the submodels available on our inhouse computer which is a PDP 11/45. In order to facilitate the use of the models descriptions of the various submodels have been elaborated. These papers are not intended to provide a description of the submodels themselves, but merely of their use (requests from the model, input, output, data). The descriptions relate to the model versions implemented on the PDP 11 under the DOS-System, which is a single job operating system.

Due to the fact that a new multiprogramming operating system (UNIX) is used on the PDP 11/45 some of the models have been implemented under UNIX too, and some of the larger models may be run as batch jobs on the CYBER 74 at the Technical University in Vienna.

Models Available at IIASA

PDP 11/45		CYBER 74 (Batch)	MODEL
DOS	UNIX		
*	*		POPULATION SUBMODEL
*	*	*	FOOD ANALYSIS MODEL
*		*	ENERGY SUPPLY MODEL
*		*	ENERGY EMISSION REGISTER
*	*		WORLD ENERGY CYCLES
*	*	*	WATER MODEL
*	*		MULTILAYER DECISION MODEL
		*	LINKED VERSION OF ENERGY SUPPLY AND ENERGY EMISSION REGISTER

THE POPULATION SUBMODEL

ABSTRACT

In the M.P. Regionalized World Model, one of the most important submodels is the population model. In its present state there are especially two purposes for which the model serves:

A. The model can be used to investigate different population policies. The model calculates an equilibrium fertility factor that would gradually lead to population equilibrium. The user of the model can specify the year when the equilibrium policy is to start, and the length of the transition interval after which the equilibrium fertility should be reached. Thus it is possible to investigate the effects of postponing the application of equilibrium policies;

B. A second feature of the model is that you may not only investigate a decreasing fertility, but also an increasing mortality due to lack of protein. This will be helpful for analysing the population growth of South East Asia.

For more details on the theoretical background see [1]

I. MATHEMATICS OF THE POPULATION MODEL

The computations of the model consist of two different periods. While the computations of the model for the years 1950-1970 are determined by the given data, various alternative strategies may be applied from 1970 on:

COMPUTER RUNS

A. Normal Runs

In the standard computer runs the fertility factor cf^t and the mortality factor cm^t are kept constant from 1970 on taking the values of 1970; i.e. $cf^t = cf^{1970}$; $cm^t = cm^{1970}$ for $t > 1970$.

B. Equilibrium Runs via Fertility Change

If you choose scenario 01-10 you will get special equilibrium runs according to the values of KONTR and INT. Mortality is kept constant, i.e. $cm^t = cm^{1970}$ for $t > 1970$; but fertility is changed (starting in year KONTR) until it reaches the value of the computed equilibrium fertility factor after a transition period of INT years.

C. Runs with Mortality Changes (Lack of Protein)

Scenario 11-33 provide runs with constant fertility but an increased mortality. The mortality multiplier ZM(X,E,a) is computed according to the values of EO,EU,EA,XO,TL. These runs are to be produced only for region 09.

D. Change of Mortality Due to Lack of Protein and Change of Fertility Due to Equilibrium Policies

For region 09 you may also choose scenario 34-53 in order to get runs that take into consideration a combination of increased mortality and equilibrium policies.

E. Scenario 99

If you specify scenario 99 you will get a run with any parameters you specify. Again lack of protein is considered only for region 09.

NOTATION

In order to simplify the documentation of the mathematics of the model the following variables will be used (different from the notation of the FORTRAN-program).

P_a^t Number of people alive on 7/1/t who were born between 7/1/t - a and 7/1/t - a + 1, i.e. people that are a years of age

T_a^t Number of people who died between 7/1/t and 7/1/t + 1, as a subset contained in P_a^t

B_a^t Number of women who gave birth to children between 7/1/t and 7/1/t + 1, as a subset of P_a^t

I_a^t Difference between immigrants and emigrants in the time-interval between 7/1/t and 7/1/t + 1, as a subset contained in P_a^t

Pop^t Total number of people alive at 7/1/t

Bab^t Babies born between 7/1/t and 7/1/t + 1

Tot^t People who died between 7/1/t and 7/1/t + 1

Imi^t Difference between immigrants and emigrants between 7/1/t and 7/1/t + 1

cbr^t Crude birth rate of year t

cdr^t Crude death rate of year t

f_a^t Age-specific fertility, i.e. the probability that a person will produce a child between 7/1/t and 7/1/t + 1 at an age between a - ½ and a + ½

m_a^t . Age-specific mortality, i.e. the probability that a person will die between 7/1/t and 7/1/t + 1 at an age between a - ½ and a + ½

cf^t Time-dependent fertility factor

af_a Age-specific fertility factor (normalization $\sum_{a=1}^{86} af_a = 1$)

cm^t Time-dependent mortality factor

am_a Age-specific mortality factor (normalization $\sum_{a=1}^{86} am_a = 1$)

LE	Life expectancy at birth
PR^t	Protein (gramm) for people in region 9 in year t
X^t	Gramm protein/capita for people in region 9
ZM_a	Age-specific mortality multiplier
KONTR	Start of equilibrium birth control
INT	Transition period to reach equilibrium fertility factor
$SBab^t$	Accumulated number of babies from 1970 on
$STot^t$	Accumulated number of deaths from 1970 on.

POPULATION DEVELOPMENT BETWEEN 1950 AND 1970

For each of the ten regions of the M.P. World Model the following data are used as initial values of the computations from 1950-1970:

P_a^{1950} $a = 1,\ldots,86$ (the age-groups were obtained by applying a spline interpolation subroutine to the available data)

$PopD^t$ $t = 1950,\ldots,1970$ Total number of population

$\left.\begin{matrix} cbr^t \\ cdr^t \end{matrix}\right\}$ $t = 1950,\ldots,1970$ Time series for the birth rates and death rates of the time-span 1950-1970

$\left.\begin{matrix} af_a \\ am_a \end{matrix}\right\}$ $a = \tfrac{1}{2},1,\ldots 86$ Age-specific fertility and mortality taken from the most recent available data and normalized such that

$$\sum_{a=1}^{86} af_a = \sum_{a=1}^{86} am_a = 1$$

SET OF BASIC EQUATIONS

$$Pop^{t} = \sum_{a=1}^{86} P_a^{t}$$

$$cf^{t} = \tfrac{1}{2} \cdot (cbr^{t} \cdot PopD^{t} + cbr^{t+1} \cdot PopD^{t+1}) / \left(\sum_{a=1}^{86} P_a^{t} \cdot af_a \right)$$

$$cm^{t} = \tfrac{1}{2} \cdot (cdr^{t} \cdot PopD^{t} + cdr^{t+1} \cdot Pop^{t+1}) / \left(\sum_{a=1}^{86} P_a^{t} \cdot am_a \right)$$

$$Imi^{t} = PopD^{t} - Pop^{t}$$

$$I_a^{t} = \begin{cases} Imi^{t}/50 & a = 2,.....,51 \\ 0 & a = 1,53,..,86 \end{cases}$$

$$P_a^{t} = P_a^{t} + I_a^{t}$$

$$Pop^{t} = Pop^{t} + Imi^{t}$$

$$Bab^{t} = \sum_{a=1}^{86} P_a^{t} \cdot af_a \cdot cf^{t}$$

$$Tot^{t} = \sum_{a=1}^{86} P_a^{t} \cdot am_a \cdot cm^{t} + \tfrac{1}{2} \cdot Bab^{t} \cdot am_{\frac{1}{2}} \cdot cm^{t}$$

$$P_{86}^{t+1} = P_{85}^{t} \cdot (1 - cm^{t} \cdot am_{85}) + P_{86}^{t} \cdot (1 - cm^{t} \cdot am_{86})$$

$$P_a^{t+1} = P_{a-1}^{t} \cdot (1 - cm^{t} \cdot am_{a-1}) \qquad a = 2,...,85$$

$$P_1^{t+1} = Bab^{t} \cdot (1 - \tfrac{1}{2} \cdot cm^{t} \cdot am_{\frac{1}{2}})$$

$$cbr^{t+\frac{1}{2}} = Bab^t/Pop^{t+\frac{1}{2}} = Tot^t/(Pop^t + \frac{1}{2} \cdot (Bab^t - Tot^t))$$

$$cdr^{t+\frac{1}{2}} = Tot^t/Pop^{t+\frac{1}{2}} = Tot^t/(Pop^t + \frac{1}{2} \cdot (Bab^t - Tot^t))$$

$$SBab^{t+1} = 0$$

$$STot^{t+1} = 0$$

The numerical output of year t provides the computed values for t, Pop^t, cf^t, $cbr^{t+\frac{1}{2}}$, cm^t, $cdr^{t+\frac{1}{2}}$, $SBab^t$, $STot^t$. In case of normal runs also $PopD^t$ and Imi^t are printed on a separate line.

POPULATION DEVELOPMENT FROM 1970 ON

From 1970 on various alternative strategies may be applied, such as equilibrium policies and the increase of mortality due to lack of protein.

SET OF BASIC EQUATIONS

$$Pop^t = \sum_{a=1}^{86} P_a^t$$

$$cf^t = \begin{cases} cf^{1970} \\ \text{according to equilibrium policy} \end{cases}$$

$$cm^t = cm^{1970}$$

$$am_a^t = \begin{cases} am_a \\ \text{according to lack of protein} \end{cases}$$

$$Bab^t = \sum_{a=1}^{86} P_a^t \cdot af_a \cdot cf^t$$

$$Tot^t = \sum_{a=1}^{86} P_a^t \cdot am_a^t \cdot cm^t + \tfrac{1}{2} \cdot Bab^t \cdot am_{\frac{1}{2}}^t \cdot cm^t$$

$$P_{86}^{t+1} = P_{85}^t \cdot (1 - cm^t \cdot am_{85}^t) + P_{86}^t \cdot (1 - cm^t \cdot am_{86}^t)$$

$$P_a^{t+1} = P_{a-1}^t \cdot (1 - cm^t \cdot am_{a-1}^t) \qquad a = 2,\ldots,85$$

$$P_1^{t+1} = Bab^t \cdot (1 - \tfrac{1}{2} \cdot cm^t \cdot am_{\frac{1}{2}}^t)$$

$$cbr^{t+\frac{1}{2}} = Bab^t/(Pop^t + \tfrac{1}{2} \cdot (Bab^t - Tot^t))$$

$$cdr^{t+\frac{1}{2}} = Tot^t/(Pop^t + \tfrac{1}{2} \cdot (Bab^t - Tot^t))$$

$$SBab^{t+1} = SBab^t + Bab^t$$

$$STot^{t+1} = STot^t + Tot^t$$

EQUILIBRIUM POLICY

In order to calculate the effects of various equilibrium policies the user of the population model may specify the values KONTR and INT as described before.

KONTR   Start of equilibrium fertility control

INT   Length of transition interval

In order to have stationary population the condition

$$Bab^t = Tot^t$$

has to be satisfied. Furthermore, the model assumes that the age-specific fertility and mortality cf_a and am_a remain constant for all times and cm is chosen to be $cm = cm^{1970}$. From this follows the condition:

$$P_a^t = P_a \qquad (a = 1,2,\ldots,86)$$

Inserting these conditions in the demographic model one gets the following relationships:

$$P_1 = Bab \cdot (1 - \tfrac{1}{2} \cdot cm \cdot am_{\frac{1}{2}})$$

$$P_{a+1} = P_a \cdot (1 - cm \cdot am_a) \qquad a = 1,\ldots,84$$

$$P_{86} = P_{85} \cdot (1 - cm \cdot am_{85}) + P_{86} \cdot (1 - cm \cdot am_{86})$$

and therefore

$$P_{86} = P_{85} \cdot (1 - cm \cdot am_{85})/(cm \cdot am_{86})$$

Defining

$$Prod(1) = 1 - \tfrac{1}{2}\, cm \cdot am_{\frac{1}{2}}$$

$$Prod(a) = Prod(a - 1) \cdot (1 - cm \cdot am_{a-1}) \qquad a = 2,\ldots,85$$

$$Prod(86) = Prod(85) \cdot (1 - cm \cdot am_{85})/(cm \cdot am_{86})$$

One gets

$$P_a = Bab \cdot Prod(a) \qquad a = 1,\ldots,86$$

Using

$$Bab = \sum_{a=1}^{86} cf^e \cdot af_a \cdot P_a$$

Leads to

$$1 = cf^e \cdot \sum_{a=1}^{86} af_a \cdot Prod(a)$$

The life expectancy at birth and the equilibrium birth rate and death rate are calculated using the relationships:

$$LE = \frac{Pop}{Bab}$$

$$cbr^{e} = cdr^{e} = \frac{Bab}{Pop} = \frac{Tot}{Pop} = 1/LE$$

SET OF EQUILIBRIUM EQUATIONS

$$\frac{P86}{P85} = (1/cm - am_{85})/\ am_{86}$$

$$Prod(1) = (1 - \tfrac{1}{2} \cdot cm \cdot am_{\frac{1}{2}})$$

$$Prod(a) = Prod(a - 1) \cdot (1 - cm \cdot am_{a-1}) \qquad a = 2,\ldots 85$$

$$Prod(86) = Prod(85) \cdot (1 - cm \cdot am_{85})/\ (am_{86} \cdot cm)$$

$$cf^{e} = 1/(\sum_{a=1}^{86} af_{a} \cdot Prod(a))$$

$$LE = \sum_{a=1}^{86} Prod(a)$$

$$cbr^{e} = 1/LE$$

$$FK^{t} = \begin{cases} 0.1 \cdot 7/INT & KONTR \leq t \leq KONTR + 2 \cdot INT/7 \\ 0.2 \cdot 7/INT & KONTR + 2 \cdot INT/7 < t \leq KONTR + 5 \cdot INT/7 \\ 0.1 \cdot 7/INT & KONTR + 5 \cdot INT/7 < t \leq KONTR + INT \end{cases}$$

$$cf^{t} = \begin{cases} cf^{1970} & 1970 < t < KONTR \\ cf^{t-1} - (cf^{1970} - cf^{e}) \cdot FK^{t} & KONTR \leq t \leq KONTR + INT \\ cf^{e} & KONTR + INT < t \end{cases}$$

LACK OF PROTEIN

In order to compute the increase of mortality due to lack of protein in region 9 of the M.P. World Model, the user may specify the values EO, EA, EU, XO and TL as described before.

SET OF INCREASED MORTALITY EQUATIONS

$$PR^{1970} = 44 \cdot Pop^{1970}$$

$$PR^{t} = \begin{cases} PR^{t-1} \cdot 1.005 & 1971 \leq t \leq 2000 \\ PR^{t-1} & 2000 < t \end{cases}$$

$$X^{t} = PR^{t}/Pop^{t}$$

$$am_a^t = ZM_a^t \cdot am_a$$

$$ZM_a^t = \left[(44 - XO)/(X^{t-TL} - XO) - 1\right] \cdot \left[(EO - EU) \cdot \exp(- a/EA) + EU\right] + 1$$

II. TERMINAL INPUT AND DATA BASE

A. Requests from the Model

Playing with the model requires the input of some specific parameters from the keyboard. For this purpose the model issues some appropriate statements on the terminal. Following each request there is an example of the expected input. These examples are primarily intended to show the user the format by which the data are to be entered rather than to give a meaningful set of data. During a session some or all of the following requests may be issued:

"SPECIFY ULTIMATE YEAR/INTERVAL"

The maximum value for the ultimate year is 2100. You may, for instance, specify 2100/05 (using format (I4, 1X, I2)) to run the model until 2100 getting an output with time-steps of 5 years. These values remain set until you finish your session.

"REGION, E.G. 08"

If you enter 01-10 (using format (I2)) you will get a "NORMAL RUN" for the specified region (see Table 1). If you enter 00 the model will ask

"GIVE POPUL. SCENARIO NUMBER, E.G. 22"

At this you must enter 01-53 or 99 (using format (I2)); if you enter anything else the model will write

"SCENARIO NUMBER NON EXISTENT"

The various scenaria are listed in Table 2. If you choose scenario number 99 the model will ask

"SPECIFY (N) EQUILIBRIUM CONTROL START/SPAN, E.G. 1975/14"

These equilibrium control parameters are used to specify a certain equilibrium policy.

"ENTER REGION"

After having specified scenario 99 you will be asked again for the region you want to run the model (since you have entered 00 at the first request); you may enter 01-10 (using format (I2)). In case you enter 09 the model will ask

"SPECIFY (N) EO,EU,EA,X0,TL
E.G. 1.0/.25/10./0.0/0.0"

These parameters influence the change of mortality due to lack of protein.

Now the model is run with the specified parameters for the region you are interested in. When the model has finished the run for your region it will ask again for a region, etc.

REMARK

You have to be careful because the parameters remain set from the last run until you reset them (i.e. by a scenario 01-53 or by means of scenario 99). Therefore, you have at first to produce the "NORMAL RUN" for the regions you are interested in, and then enter special scenaria.

The terms appearing in the above requests denote the following:

ULTIMATE YEAR : Last year to run the model ($\leq$ 2100)

INTERVAL : Time steps for the line printer output

REGION : In the M.P. World Model, the world has been regionalized. There are ten regions:-

Table 1

NR.	REGION
01	North America
02	Western Europe
03	Japan
04	Rest of Developed (i.e. Israel Australia, New Zealand)
05	East Europe and USSR
06	Latin America
07	Middle East
08	Main Africa
09	South East Asia
10	China

POPUL. SCENARIO NUMBER (= NSC)

There are 53 scenaria 01-53 with special sets of parameters available (Table 2). If you want to specify your own parameters you must enter 99. In any case lack of protein is only considered for region 09 (i.e. South East Asia). Therefore, scenario 11-53 ought to be run only for this region.

EQUILIBRIUM CONTROL START (= KONTR)

Start of the equilibrium policy; must be a multiple of 5, e.g. 1975, 1990, 2000, etc.

EQUILIBRIUM CONTROL SPAN (= INT)

Lenth of transition interval; number of years from the start of the equilibrium policy until the equilibrium fertility factor is reached; must be a multiple of 7, e.g. 0, 14, 35, etc.

EO : Sensitivity of babies to protein deficiency

EU : Sensitivity of older people to protein deficiency

EA : Time constant that indicates the number of years that pass until E(a) - EU drops to 37% of EO - EU, where E(a) is defined as:

$$E(a) = (EO - EU) \cdot \exp(- a/EA) + EU$$

("age-specific sensitivity to protein deficiency")

XO : Minimal per capita protein consumption (in gramm) per day. If protein consumption/day $\leq$ XO all people die due to lack of protein

TL : Time delay in the effect of protein deficiency (in years). Using these parameters an age-specific mortality multiplier is defined:

$$ZM(X,E,a) = \left[\frac{44 - XO}{X(T - TL) - XO} - 1\right] \cdot E(a) + 1$$

Where X(T) is the computed per capita protein consumption for year T and E the above defined sensitivity to protein deficiency

B. DATA BASE

To run the model two data files are needed. From unit number 4 the following time series and age distribution are read (Format (19X, 6 F10.5)).

MIDYEAR POP : Estimates for the aggregate midyear population of the respective region are given from 1950 to 1970. Data are given in millions of inhabitants.

ANFANGSVERT : Age distribution in 1950 or for the earliest available year, the age distribution is normalized to sum up to 1 and presented in the following way:

Babies less than 1 year, 1 to 5 year olds,....,80 to 85 year olds, and people older than 85 years.

AF : Age-specific fertility calculated from the latest available historical data according to:

$$AF_a = \frac{B_a}{Bab} / \frac{P_a}{Pop} \qquad a = 1,...,11$$

In this context 'a' does not denote a single one-year age group, but five-year age groups. Furthermore, the first figure given is always 1.0, so age-specific fertility rates AF include: 1.0, 10-15 year-olds,..., 45-50 year-olds, older than 50, unknown births.

AM : Age-specific mortality calculated from the latest available data according to:

$$AM_a = \frac{T_a}{Tot} / \frac{P_a}{Pop} \qquad a = 1,...,21$$

As before the first figure given is 1.0. Thus AM include: 1.0, babies less than 1, 1-5 year-olds, 5-10 year olds,..., 80-85 year-olds, people older than 85, and unknown deaths

CDR : 21 values denoting the crude birth rates from 1951-1971 are given

CBR : 17 figures are listed, the first of which is the average crude birth rate for the years 1950-1954. The remaining 16 values denote the birth rates from 1955-1969.

All the data dealt with above are listed for each of the ten regions. A listing of the data is given below. As for the UNIX-operating-system a file called PDAT.D, which has to contain all data is associated with unit number 4. Under DOS the respective file is called PDAT.DAT. A second file is needed to read the prepared scenario data using unit number 9. The corresponding FORMAT is (1X,2(F2.0,1X), F4.0,1X,F2.0,1X,6(F3.1,1X)). Each line contains the following values:

SCENARIO LABEL, SCENARIO NUMBER, KONTR, INT, EO, EU, EA, XO, and TL

The SCENARIO LABEL is used for classifying the various scenaria, i.e. all scenaria dealing with population policies only take a value 01, those investigating lack of protein take 02, etc.

The remaining 8 variables have been already described in section A. of this chapter. The actual file names are SCEDAT.D and SCEDAT.DAT for UNIX and DOS respectively.

Table 2

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01	01	2200						
01	02	1975						
01	03	19[illegible]5						
01	04	1995						
01	05	1975	14					
01	06	1985	14					
01	07	1995	14					
01	08	1975	35					
01	09	1985	35					
01	10	1995	35					
02	11					10.	10.	15.
02	12					10.		15.
02	13					20.		15.
02	14					20.		
02	15			1.0	.25	10.	10.	10.
02	16			1.0	.25	10.	10.	5.
02	17			1.0	.25	10.	10.	
02	18			1.0	.25	10.	5.	
02	19			1.0	.25	10.		10.
02	20			1.0	.25	10.		5.
02	21			1.0	.25	10.		
02	22			1.0	.25	5.		
02	23			1.0	.5	20.		
02	24			1.5	.25	10.		
02	25			1.5	.5	10.		
02	26			2.0	.25	20.		
02	27			2.0	.25	10.		
02	28			2.0	.25	5.		
02	29			2.0	.5	20.		10.
02	30			2.	.5	20.		5.
02	31			2.	.5	20.		
02	32			2.	.5	5.		
02	33			2.	.5	5.	10.	
03	34	1975	14			20.		
03	35	1985	14			20.		
03	36	1995	14			20.		
03	37	2200	14			20.		
03	38	1985	14			10.		
03	39	2200	14			10.		
03	40	1975	14			5.0		
03	41	1985	14			5.0		
03	42	1995	14			5.0		
03	43	2200	14			5.0		
03	44	1975	14	1.0	.25	5.		
03	45	1985	14	1.0	.25	5.0		
03	46	1995	14	1.0	.25	5.0		
03	47	2200	14	1.0	.25	5.0		
03	48	1985	14	1.5	.25	10.		
03	49	2200	14	1.5	.25	10.		
03	50	1975	14	2.0	.50	20.		
03	51	1985	14	2.0	.50	20.		
03	52	1995	14	2.0	.50	20.		
03	53	2200	14	2.0	.50	20.		

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NORTH AMERICA						
MIDYEAR POP R1	166.01	168 93	172.05	175.07	178.36	181.67
MIDYEAR POP R1	[illegible]	[illegible]	192.[illegible]	195.35	198.59	202.03
MIDYEAR POP R1	[illegible]	[illegible]	[illegible]	214.26	216.96	219.55
MIDYEAR POP R1	221.95	224 30	226.81			
ANFANGSVERT. R1	1.0	0.0 14	0.0668	0.0883	0.0745	0.0711
ANFANGSVERT. R1	0.0766	0.0 12	0.0763	0.0743	0.0672	0.0596
ANFANGSVERT. R1	0.0543	0.0 75	0.0399	0.0330	0.0226	0.0111
ANFANGSVERT. R1	0.0106	0.0 38	0.0			
AF R1	1.0	0.0 7	2.074	5.771	4.669	2.141
AF R1	0.960	0.2 7	0.021	0.0	0.004	
AM R1	1.0	2.3 8	0.092	0.046	0.044	0.113
AM R1	0.143	0.1 6	0.178	0.259	0.396	0.617
AM R1	0.959	1.4 8	2.216	3.316	5.011	7.197
AM R1	10.979	20. 89				
CDR 51-71 REGION 1	9.63	9.5	9.50	9.09	9.19	9.19
CDR 51-71 REGION 1	9.46	9.3	9.26	9.34	9.14	9.33
CDR 51-71 REGION 1	9.43	9.2	9.23	9.50	9.21	9.48
CDR 51-71 REGION 1	9.29	9.2	9.11			
CBR(50-54),54-69 R1	24.80	25. 2	25.01	25.19	25.29	24.60
CBR(50-54),54-69 R1	24.41	23. 8	23.55	22.67	21.97	21.23
CBR(50-54),54-69 R1	19.58	18. 8	17.82	17.50	17.69	
WESTERN EUROPE						
MIDYEAR POP R2	322.79	325 45	328.02	330.87	333.85	336.83
MIDYEAR POP R2	339.86	343 29	346.61	350.06	353.51	357.35
MIDYEAR POP R2	361.62	365 70	369.59	373.52	377.31	380.62
MIDYEAR POP R2	383.88	387 54	391.48			
ANFANGSVERT. R2	1.0	0.0 88	0.0747	0.0804	0.0825	0.0807
ANFANGSVERT. R2	0.0807	0.0 80	0.0597	0.0708	0.0718	0.0660
ANFANGSVERT. R2	0.0577	0.0 73	0.0419	0.0342	0.0263	0.0164
ANFANGSVERT. R2	0.0081	0.0 38	0.0001			
AF R2	1.0	0.0 3	0.990	4.224	4.582	3.000
AF R2	1.483	0.4 0	0.046	0.0	0.064	
AM R2	1.0	3.2 7	0.101	0.041	0.039	0.068
AM R2	0.085	0.0 9	0.115	0.174	0.263	0.411
AM R2	0.702	0.9 4	1.723	2.704	4.345	6.929
AM R2	12.858	18. 21	27.019			
CDR 51-71 R2	11.50	10. 9	10.94	10.40	10.84	10.92
CDR 51-71 R2	10.75	10. 5	10.57	10.52	10.26	10.63
CDR 51-71 R2	10.74	10. 8	10.27	10.30	10.67	10.61
CDR 51-71 R2	10.78	10. 3	10.59			
CBR(50-54),54-69 R2	20.87	20. 1	20.51	18.42	18.59	18.51
CBR(50-54),54-69 R2	18.74	18. 5	18.93	16.88	19.05	19.32
CBR(50-54),54-69 R2	18.79	20. 9	18.00	17.48	17.03	
JAPAN						
MIDYEAR POP R3	82.90	84. 4	85.50	86.69	87.98	89.02
MIDYEAR POP R3	89.95	90. 3	91.55	92.43	93.22	94.06
MIDYEAR POP R3	94.93	95. 0	96.90	97.95	98.86	99.92
MIDYEAR POP R3	101.08	102 32	103.54			
ANFANGSVERT. R3	1.0	0.0 78	0.1068	0.1145	0.1046	0.1030
ANFANGSVERT. R3	0.0929	0.0 43	0.0625	0.0607	0.0539	0.0481
ANFANGSVERT. R3	0.0407	0.0 30	0.0277	0.0213	0.0154	0.0082
ANFANGSVERT. R3	0.0033	0.0 11	0.0001			
AF R3	1.0	0.0	0.123	2.890	5.948	2.492
AF R3	0.619	0.0 9	0.005	0.0	0.0	
AM R3	1.0	2.2 9	0.165	0.073	0.050	0.101

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AM	R3	0.146	0.1 5	0.229	0.291	0.405	0.594
AM	R3	0.948	1.5 1	2.543	4.201	7.073	12.026
AM	R3	19.772	32. 89				
CDR 51-71	R3	10.0	8.8	8.89	8.19	7.79	8.09
CDR 51-71	R3	8.30	7.5	7.50	7.59	7.4	7.50
CDR 51-71	R3	7.00	6.9	7.09	6.79	6.79	6.79
CDR 51-71	R3	6.79					
CBR	R3	23.69	27. 0	19.39	18.50	17.29	18.10
CBR	R3	17.60	17. 9	16.89	17.10	17.29	17.69
CBR	R3	18.60	18. 9	19.39	18.6		
REST OF DEVELOPED							
MIDYEAR POP	R4	26.17	27. 1	27.71	28.41	29.19	29.92
MIDYEAR POP	R4	30.66	31. 6	32.20	32.98	33.74	34.57
MIDYEAR POP	R4	35.41	36. 1	37.07	37.92	38.77	39.58
MIDYEAR POP	R4	40.44	41. 8	42.30			
ANFANGSVERT.	R4	1.0	0.0 24	0.0902	0.0951	0.0793	0.0783
ANFANGSVERT.	R4	0.0923	0.0 39	0.0842	0.0582	0.0548	0.0620
ANFANGSVERT.	R4	0.0534	0.0 43	0.0347	0.0264	0.0171	0.0146
ANFANGSVERT.	R4	0.0048	0.0 39	0.0203			
AF	R4	1.0	0.0 7	1.810	5.709	3.614	2.058
AF	R4	1.012	0.3 1	0.030	0.001	0.002	
AM	R4	1.0	3.5 6	0.131	0.051	0.039	0.075
AM	R4	0.111	0.1 8	0.149	0.202	0.296	0.445
AM	R4	0.708	0.9 3	1.868	3.112	5.176	9.302
AM	R4	12.704	18. 39				
CDR	R4	7.70	8.0	9.57	9.69	9.48	9.75
CDR	R4	8.45	8.0	8.39	8.05	8.01	8.15
CDR	R4	8.22	8.3	8.13	8.28	8.32	8.44
CDR	R4	8.43	8.7	8.69			
CBR	R4	30.60	30. 2	30.26	30.23	30.27	30.15
CBR	R4	30.28	30. 6	30.04	29.74	29.48	29.05
CBR	R4	26.13	25. 3	25.71	25.85	28.73	
EAST EUROPE AND USSR							
MIDYEAR POP	R5	269.79	273 72	277.80	281.85	285.99	290.50
MIDYEAR POP	R5	294.92	299 13	303.56	308.10	312.63	317.22
MIDYEAR POP	R5	321.46	325 59	329.35	332.87	336.03	339.09
MIDYEAR POP	R5	342.43	345 48	348.53			
ANFANGSVERT.	R5	1.0	0.0 92	0.1124	0.1202	0.1014	0.0862
ANFANGSVERT.	R5	0.0841	0.0 95	0.0687	0.0640	0.0565	0.0477
ANFANGSVERT.	R5	0.0396	0.0 19	0.0262	0.0196	0.0140	0.0089
ANFANGSVERT.	R5	0.0053	0.0 35	0.0006			
AF	R5	1.0	0.0 9	1.141	5.070	5.001	2.754
AF	R5	1.126	0.3 0	0.037	0.001	0.007	
AM	R5	1.0	2.2 5	0.131	0.049	0.043	0.122
AM	R5	0.145	0.1 2	0.145	0.214	0.338	0.554
AM	R5	0.914	1.4 5	2.370	3.854	5.759	9.248
A4	R5	14.146	25. 43	339477.6			
CDR	R5	10.39	10. 1	9.63	9.48	8.76	8.31
CDR	R5	8.53	7.8	8.34	7.74	7.82	8.15
CDR	R5	7.78	7.5	7.93	7.87	8.22	8.36
CDR	R5	8.50					
CBR	R5	25.73	25. 0	25.19	24.52	24.38	24.02
CBR	R5	23.55	23. 4	22.18	20.94	20.08	19.10
CBR	R5	17.76	17. 8	17.61	17.43	17.70	
LATIN AMERICA							
MIDYEAR POP	R6	161.55	165 78	170.12	174.64	179.34	184.36

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MIDYEAR POP R6	[illegible]	195 39	[illegible]	[illegible]7.77	212.62	218.87
MIDYEAR POP R6	225.24	231 85	236.75	245.86	253.15	260.62
MIDYEAR POP R6	268.32	276 35	284.75			
ANFANGSVERT. R6	1.0	0.0 24	0.1181	0.1326	0.1158	0.0999
ANFANGSVERT. R6	0.0906	0.0 79	0.0635	0.0611	0.0487	0.0418
ANFANGSVERT. R6	0.0345	0.0 42	0.0222	0.0136	0.0098	0.0052
ANFANGSVERT. R6	0.0035	0.0 27	0.0018			
AF R6	1.0	0.0 1	1.467	3.955	4.330	3.105
AF R6	2.458	1.2 1	0.168	0.031	0.536	
AM R6	1.0	7.1 1	0.894	0.193	0.114	0.172
AM R6	0.258	0.3 8	0.362	0.516	0.605	0.834
AM R6	1.115	1.6 8	2.548	4.048	5.488	7.713
AM R6	12.865	24. 88	109.123			
CDR R6	13.84	12. 9	12.91	11.70	11.93	10.95
CDR R6	11.50	10. 1	10.14	11.56	11.56	11.56
CDR R6	11.56	11. 6	11.56	9.42	9.28	10.45
CDR R6	10.00	9.9	7.40			
CBR R6	39.94	38. 9	39.17	38.98	38.64	38.30
CBR R6	36.91	41. 4	41.13	41.13	41.13	41.13
CBR R6	40.62	36. 1	35.44	40.11	40.53	
MIDDLE EAST						
MIDYEAR POP R7	81.65	83. 3	85.45	87.69	89.75	92.27
MIDYEAR POP R7	94.63	97. 0	99.49	102.12	104.80	107.64
MIDYEAR POP R7	110.10	113 09	115.68	119.46	122.28	125.81
MIDYEAR POP R7	129.45	133 30	135.51			
ANFANGSVERT. R7	1.0	0.0 23	0.1428	0.1475	0.1138	0.0829
ANFANGSVERT. R7	0.0725	0.0 37	0.0652	0.0579	0.0455	0.0395
ANFANGSVERT. R7	0.0349	0.0 62	0.0238	0.0149	0.0114	0.0060
ANFANGSVERT. R7	0.0041	0.0 41	0.0007			
AF R7	1.0	0.0 3	0.893	3.601	4.726	4.245
AF R7	3.440	1.3 1	0.423	0.071	0.413	
AM R7	1.0	7.6 6	0.894	0.233	0.168	0.21
AM R7	0.287	0.3 7	0.387	0.459	0.559	0.785
AM R7	1.037	1.5	2.534	3.358	4.703	6.234
AM R7	10.931	19. 16	15645.0			
CDR R7	12.48	11. 7	12.13	11.93	12.09	15.53
CDR R7	16.06	16. 4	16.30	16.48	15.95	12.17
CDR R7	10.47	10. 0	10.85	14.33	13.46	16.20
CDR R7	13.65	14. 7	11.89			
CBR R7	43.61	37. 5	39.29	37.81	37.41	38.86
CBR R7	40.31	41. 5	36.43	39.29	39.88	38.67
CBR R7	38.29	37. 4	36.43	37.19		
MAIN AFRICA						
MIDYEAR POP R8	161.73	164 88	168.17	171.92	175.53	179.62
MIDYEAR POP R8	182.61	186 81	191.11	195.46	199.20	204.85
MIDYEAR POP R8	209.72	214 77	219.67	225.00	230.31	235.71
MIDYEAR POP R8	241.34	247 16	252.85			
ANFANGSVERT. R8	1.0	0.0 35	0.1390	0.1510	0.1037	0.0857
ANFANGSVERT. R8	0.0918	0.0 76	0.0740	0.0555	0.0484	0.0338
ANFANGSVERT. R8	0.0287	0.0 62	0.0156	0.0088	0.0073	0.0049
ANFANGSVERT. R8	0.0049	0.0 50	0.0006			
AF R8	1.0	0.2	1.694	3.318	4.144	2.740
AF R8	2.00	0.8 5	0.508	0.064	0.0	
AM R8	1.0	4.9 6	1.332	0.362	0.360	0.465
AM R8	0.534	0.4 3	0.558	0.584	0.800	0.842
AM R8	1.226	1.4 1	2.134	2.441	3.047	4.492

AM	R8	6.0	9.0	36.253			
CDR	R8	16.42	16. 8	13.93	12.66	13.90	15.97
CDR	R8	16.65	16. 1	16.60	16.93	20.00	
CDR	R8	0.0					
CDR	R8	0.0					
CBR	R8	35.66	33. 0	44.26	37.09	43.63	38.65
CBR	R8	40.29	42. 0				
CBR	R8	0.0					
SOUTH EAST ASIA							
MIDYEAR POP	R9	725.12	735 06	749.29	764.21	779.96	796.18
MIDYEAR POP	R9	813.56	831 59	857.37	877.00	897.53	918.98
MIDYEAR POP	R9	941.72	964 95	988.60	1016.56	1041.98	1068.14
MIDYEAR POP	R9	1096.26	112 .37	1153.11			
ANFANGSVERT.	R9	1.0	0.0 35	0.1150	0.1419	0.1100	0.0945
ANFANGSVERT.	R9	0.0843	0.0 97	0.0697	0.0617	0.0520	0.0428
ANFANGSVERT.	R9	0.0356	0.0 53	0.0201	0.0129	0.0063	0.0052
ANFANGSVERT.	R9	0.0046	0.0 46	0.0002			
AF	R9	1.0	0.0 8	0.382	1.829	2.473	1.958
AF	R9	1.222	0.4 8	0.118	0.011	0.156	
AM	R9	1.0	6.9 2	1.453	0.327	0.190	0.225
AM	R9	0.279	0.3 3	0.389	0.439	0.527	0.701
AM	R9	1.020	1.4 7	2.373	2.797	4.237	6.239
AM	R9	8.214	12.	1.0			
CDR	R9	23.23	23. 3	21.60	21.52	19.58	18.97
CDR	R9	16.47	16. 5	16.75	16.10		
CDR	R9	0.0					
CDR	R9	0.0					
CBR	R9	43.41	43. 5	43.08	41.15	39.33	39.70
CBR	R9	39.76	40. 3	39.65	41.58	39.24	39.77
CBR	R9	40.00	42. 0				
CHINA							
MIDYEAR POP	R10	554.68	563 48	573.29	583.86	594.75	605.84
MIDYEAR POP	R10	617.04	628 43	639.93	651.60	663.52	675.61
MIDYEAR POP	R10	688.08	700 92	713.98	727.20	740.59	754.19
MIDYEAR POP	R10	767.99	781 93	795.95			
ANFANGSVERT.	R10	1.0	0.0 16	0.1261	0.1320	0.1201	0.1101
ANFANGSVERT.	R10	0.0814	0.0 71	0.0647	0.0547	0.0493	0.0446
ANFANGSVERT.	R10	0.0322	0.0 92	0.0218	0.0184	0.0090	0.0052
ANFANGSVERT.	R10	0.0018	0.0 08	0.0			
AF	R10	1.0	0.0 82	0.363	1.669	2.560	4.249
AF	R10	2.169	0.6 5	0.077	0.006	0.87	
AM	R9	1.0	6.9 2	1.453	0.327	0.190	0.225
AM	R9	0.279	0.3 3	0.389	0.439	0.527	0.701
AM	R9	1.020	1.4 7	2.373	2.797	4.237	6.239
AM	R9	8.214	12.	1.0			
CDR	R10	19.0	18. 0	17.00	15.00		
CDR	R10	0.0					
CDR	R10	0.0					
CDR	R10	0.0					
CBR	R10	37.12	38. 0	34.99	31.98	34.22	33.50
CBR	R10	[illegible]					
CBR	R10	33.5[illegible]					

III. OUTPUT

The head of the printout contains the name of the chosen region, the scenario number (or NORMAL RUN) and the values of the various parameters (i.e. KONTR,INT,EO,EU,EA,XO,TL). Then you get a table consisting of eight columns:

YEAR : Year t of consideration, $1950 \leq t \leq$ ULTIMATE YEAR

TOTAL POP : Total number of people living in year t as computed by the model for the specified region

FERTILITY : Computed fertility factor cf^t for $1950 \leq t \leq 1970$. For $t > 1970$ the fertility factor is either constant (i.e. $cf^t = cf^{1970}$) or determined by the chosen equilibrium policy

BAB/POP : Ratio of babies born in year t to total end-year population in t, i.e. crude birth rate $cbr^{t+\frac{1}{2}}$

MORTALITY : Computed mortality factor cm^t for $1950 \leq t \leq 1970$. For $t > 1970$ the mortality factor is kept constant (i.e. $cm^t = cm^{1970}$)

TOT(N)/POP : Ratio of people that died in year t to total (end-year) population in year t, i.e. crude death rate $cdr^{t+\frac{1}{2}}$

SUMME BAB(N) 70: Accumulative sum of all babies from 1970 on

SUMME TOT(N) 70: Accumulative sum of all deaths from 1970 on.

Subsequent to the line printed for 1970 you find a few data concerning the equilibrium state:

LE : Life expectancy at birth

CFSTAT : Fertility factor cf^e leading to equilibrium

TOT/BAB : Ratio of babies to deaths for equilibrium (= 1.0)

P86/P85 : Ratio of people that are older than 85 years to number of people that are 85 years old.

If you have performed a NORMAL RUN you will also get the actual population (from data), and the calculated number of immigrants (both in millions); i.e. the calculated difference between the computed population number and the actual value.

```
      DIMENSION PP1(1),GLB(1),DCH(1)
      DIMENSION SCE(10,50)
      DIMENSION FER(21,1),AMOR(21,1)
      DIMENSION FERT(21),AMORT(21),CF(21),CM(20),G(21)
      COMMON SCE,FER,AMOR,FERT,AMORT,CF,CM,G
66     CALL SETFIL(4,"PDAT.D ")
        CALL SETFIL(9,"SCEDAT.D ")
      IYT = 1950
      ISTAT = 1970
      ISS = 1950
      WRITE(6,6)
      READ(5,7) MAXIYR,INTER
      NCO = 0
        WRITE(6,154)
        READ(5,5)I
      CALL POPUL(-1,IYT,I,PP1(1),GLB(1),DCH(1),NCO,PROV,NALL)
      REWIND 9
      REWIND 4
2     DO 1  J=1,151
      IYR = J+1949
      IF(IYR.GT. MAXIYR) GOTO 66
      CALL ALLPR(IYR,ISS,MAXIYR,INTER,NALL)
      CALL POPUL (ISTAT,IYR,I,PP1(1),GLB(1),DCH(1),NCO,PROV,NALL)
1     CONTINUE
      GOTO 66
5      FORMAT(I2)
6     FORMAT(///,'SPECIFY ULTIMATE YEAR / INTERVAL  ',/)
7     FORMAT(I4,1X,I2)
154    FORMAT(' REGION ,E.G. 08',/)
99    STOP
      END
      SUBROUTINE POPUL(ISTAT,IYR,I1,GT,GRP4,TOTK,NFO,PROV,NALL)
      DIMENSION AP2(86,1),AF2(86,1),AM2(86,10),SCE(10,60)
      DIMENSION FER(21,1),AMOR(21,1)
      DIMENSION GSW(21),GP(21),GF(21),GM(21),POP(21),G(21)
      DIMENSION FERT(21),AMORT(21),CF(20,1),CM(20,1)
      DIMENSION AP(86,1),AM3(86,1),AF(86,1),AP1(86),AF1(86),AM1(86)
      DIMENSION NAME(12,1),XP(151),AM(86,1),POP2(21,1)
      DIMENSION SBAB(1),STOT(1),TOT(1),BAB(1),GT(1),AM0(1)
      DIMENSION AMIG(1),CB(1),CD(1)
      DIMENSION S1(1),S2(1),FY(1),FX(1),PG(1),F(1),FA(1),GRP4(1)
      DIMENSION CBR(1),CDR(1),TOTK(1)
      REAL*8 CB,CF,CD,AM,AM0,P,S1,S2,S3,A85,FY,FX,F,FA
        REAL INT,INTV
C
      NDATA=0
      IF(ISTAT)1,2,3
1     IF(NDATA.EQ.1)GOTO 2
      IF(I1 .EQ. 0) GOTO 161
      NDATA=1
       KREG=1
        DO 200 IPT1=1,I1
C
C     READ PRIMARY DATA
C
      READ(4,104)(NAME(L,KREG),L=1,12)
```

```
      READ(4,1Ø9)POP
      READ(4,1Ø9)G5Ø
      DO 14Ø L=1,2Ø
140   GF(L) = Ø.Ø
      READ(4,1Ø9)P,(GF(I),I=5,13)
      READ(4,1Ø9)GM
      READ(4,1Ø9)(AMORT(I),I=2,21),P
      READ(4,1Ø9) (FERT(I),I=4,21)
2ØØ     CONTINUE
C
C     ADJUST AMORT,FERT DATA
C
      DO 141 L=1,3
141   FERT(L) = FERT(4)
      AMORT(1) = AMORT(2)
      DO 143 L=2,21
      IF(AMORT(L))146,146,1477
146   AMORT(L)=AMORT(L-1)
1477  CONTINUE
      IF (FERT(L)) 143,142,143
142   FERT(L) = FERT(L-1)
143   CONTINUE
      DO 145 L=1,21
      AMORT(L) = AMORT(L) * .ØØ1
145   FERT(L) = FERT(L)*.ØØ1
C
C     CALCULATE SECONDARY DATA AP1,AF1,AM1
C
      CALL SPLINE (G5Ø,AP1,1,2Ø)
      GM(2) = GM(2)*.2
      GM(3) = GM(3)*.8
      GM(2Ø) = GM(2Ø)*.2
      CALL SPLINE (GM,AM1,2,2Ø)
      N = 4
152   N=N+1
      IF (GF(N)) 152,152,153
153   N1 = N-1
      N = 14
154   N=N-1
      IF (GF(N)) 154,154,155
155   N2 = N
      GF(1) = Ø.1
      CALL SPLINE (GF,AF1,N1,N2)
C
C     SAVE DATA FOR ALL REGIONS
C
      DO 16Ø L=1,86
      AP2(L,KREG)=AP1(L)*POP(1)*1.E6
16Ø   AM2(L,KREG)=AM1(L)
      DO 19Ø   L=1,85
19Ø   AF2(L,KREG)=(AF1(L)+AF1(L+1))*.5
      DO 734 L=1,21
      FER(L,KREG)=FERT(L)
      AMOR(L,KREG)=AMORT(L)
734    POP2(L,KREG)=POP(L)
      IF(KONTR .EQ. Ø) KONTR = 22ØØ
```

```
161     DO 201 I =1,53
        READ(9,149) (SCE(J,I),J=1,10)
        IF(SCE(1,I))201,2,201
201     CONTINUE
2       CONTINUE
        IF(I1 .EQ. 0) GOTO 3
        RETURN
3       IF(IYR-1950) 167,167,168
C
C       INITIALISATION FOR 1950
C
167     IF(I1.EQ.0)GOTO 187
        I=1
        N1=1
        N2=1
        DO 54 N=N1,N2
        CBR(N)=0.0
        CDR(N)=0.0
        CB(N)=0.0
        CD(N)=0.0
        AM0(N)=AM2(1,N)
        DO 166 L=1,86
        AP(L,N)=AP2(L,N)
        AF(L,N)=AF2(L,N)
166     AM(L,N)=(AM2(L,N)+AM2(L+1,N))*.5
        AM(86,N)=AM2(66,N)
        DO 704 L=1,86
704     AM3(L,N)=AM2(L,N)
        SBAB(N) = 0.
54      STOT(N) = 0.
          LAUS=1
C
C       INTERACTIVE MODULE
C
187     IF(I1.GE.1.AND.I1.LE.10)GOTO 1685
        NPI=0
        IF(I1.GT.10)NPI=1
        WRITE(6,169)
        READ(5,170)NSC
        RSC=NSC
        KONTR=2200
        INT=140000.
        ED=0.0
        EU=0.0
        EA=0.0
        X0=0.0
        TL=0.0
        IF(NSC-99)197,176,176
197     IF(NSC)2,181,172
172     DO 173  I2=1,60
        IF(SCE(2,I2)-RSC)173,174,173
173     CONTINUE
        WRITE(6,175)
        GOTO 187
174     KONTR=SCE(3,I2)
        INT=SCE(4,I2)
```

```
      EO=SCE(5,I2)
      EU=SCE(6,I2)
      EA=SCE(7,I2)
      X0=SCE(8,I2)
      TL=SCE(9,I2)
       IF(SCE(1,I2)  .EQ.2) KONTR = 2200
      WRITE(6,913)
      READ(5,914) I12
      I1 = I12
      GOTO 181
176   WRITE(6,177)
      READ(5,178)KONTR,INT11
        WRITE (6,913)
913     FORMAT(1X,'ENTER REGION',/)
      READ(5,914) I12
      I1 = I12
914     FORMAT(I2)
        INT=INT11
1761   CONTINUE
      IF(I1.NE.9)GOTO 1762
      WRITE(6,179)
      READ(5,180)EO,EU,EA,X0,TL
1762  CONTINUE
181   KTOT=TL
      LAUS=(KONTR-1970)/5
      IF(LAUS-5)317,317,313
313   LAUS=10
317   IF(INT-100)1681,1681,316
316   LAUS=1
1681  KAB=INT/7
      GOTO 1
C
C     WRITE HEADLINE
C
1685  INTV=INT
      IF(INT-100) 718,719,719
719   INTV=0
718   IF(NALL)168,901,168
901   IF(NSC)961,962,961
961   WRITE(6,656)(NAME(L,1),L=1,12),NSC,KONTR,INTV,EO,EU,EA,X0,TL
      GOTO 963
962   WRITE(6,654)(NAME(L,1),L=1,12),KONTR,INTV
963   WRITE(6,108)
C
C     MODEL
C
168   IF(I1.EQ.0)RETURN
      KK=IYR-1949
      K=IYR
      DO 55 N=N1,N2
      GT(N) = 0.
      TOT(N) = 0.
      BAB(N) = 0.
      DO 5 L=1,86
      TOT(N) = TOT(N) + AP(L,N)*AM(L,N)
5     BAB(N) = BAB(N)+AP(L,N)*AF(L,N)
```

```
      DO 7 L=1,18
7     G(L) = 0.
      DO 8 L=1,86
      L2 = (L+4)/5
8     G(L2) = G(L2)+AP(L,N)
      DO 9 L=1,18
9     GT(N) = GT(N)+G(L)
55    CONTINUE
C
C     MIGRATION
C
      IF (K-1970) 90,90,97
90    DO 56 N=N1,N2
      AMIG(N) = POP2(KK,N)*100.-GT(N)*0.0001
      IF(AMIG(N))91,92,92
91    AMIG(N)=AMIG(N)-1.0
92    AMIG(N) = AMIG(N)+.5
      MIG = AMIG(N)
      DO 95 L=2,51
95    AP(L,N) = AP(L,N)+MIG*200.
      AMIG(N) = MIG*.01
56    GT(N) = GT(N) + MIG*1.E4
       XP(KK) = 44.
97    IF(NALL)1515,150,1515
150   XTOT=STOT(I)/1.E6
      XBAB=SBAB(I)/1.E6
      XGT = GT(I)/1.E6
      WRITE(6,151)K,XGT,CB(I),CBR(I),CD(I),CDR(I),XBAB,XTOT
1515  IF (K-1970) 10,30,50
C
C     MORTALITY,FERTILITY TILL 1969
C
10    DO 57 N=N1,N2
      BB = (FER(KK,N)*POP2(KK,N)+FER(KK+1,N)*POP2(KK+1,N))*.5E6
      TT = (AMOR(KK,N)*POP2(KK,N)+AMOR(KK+1,N)*POP2(KK+1,N))*.5E6
      IF (AMOR(KK+1,N)) 11,11,12
11     TT = (POP2(KK,N)-POP2(KK+1,N))*1.E6 + BB
12    TOT(N) = TOT(N)+BB*.5*AM0(N)
      CB(N) = BB/BAB(N)
      CD(N) = TT/TOT(N)
      CF(KK,N) = CB(N)
57    CM(KK,N) = CD(N)
      IF(NALL+NSC)80,801,80
801   WRITE(6,112)POP2(KK,1),AMIG(1)
      GO TO 80
C
C     CALCULATION OF EQUILIBRIUM STATE AND MORT. MULTIPL. (PROTEIN)
C
30    IF(NALL+NSC)300,301,300
301   WRITE(6,112)POP2(KK,1),AMIG(1)
300   DO 58 N=N1,N2
      CB(N) = 0.
      CD(N) = 0.
      DO 35 L=1,LAUS
      L1 = KK-L
      CB(N) = CB(N)+CF(L1,N)
```

```
35      CD(N) = CD(N)+CM(L1,N)
        C8(N) = CM(N)/LAUS
        CD(N) = CD(N)/LAUS
        PG(N) = (1./CD(N)-AM(85,N))/AM(86,N)
        P = 1.-.5*CD(N)*AMØ(N)
        S1(N) = P
        S2(N) = AM(1,N)*CD(N)*P +1. -P
        S3 = Ø.
        DO 4Ø L=2,85
        P = P*(1.-AM(L-1,N)*CD(N))
        S1(N) = S1(N)+P
        S3 = S3 + AF(L,N)*P
4Ø      S2(N) = S2(N)+AM(L,N)*CD(N)*P
        A85 = (1.-(1.-S2(N))/P)/CD(N)
        P = P*(1.-AM(85,N)*CD(N))
        S1(N) = S1(N)+P/AM(86,N)/CD(N)
        S2(N) = S2(N)+P
        FY(N) = 1./S1(N)
        FX(N) = 1./S3
        F(N)=C8(N)
58      FA(N)=F(N)-FX(N)
        IF(NALL)7ØØ,7Ø1,7ØØ
7Ø1       WRITE(6,41)S1(1),FX(1),FY(1),S2(1),PG(1)
7ØØ     PR = 44.*GT(1)
        PRD = PR*Ø.ØØ5
        GO TO 8Ø
C
C       MORTALITY,FERTILITY LATER THAN 197Ø
C
5Ø      IF(EO+EA+EU+XØ+TL.EQ.Ø)GOTO 3Ø65
        IF(I1-9)3Ø65,5ØØ,3Ø65
5ØØ     IF(K-2ØØØ)23Ø,23Ø,235
23Ø     PR = PR+PRD
        IF(NFO-1)235,1677,235
1677    PR=PROV
235      XP(KK) = PR/GT(1)
         DO 24Ø   L=1,85
        E=EU
        IF(EO.EQ.EU.OR.EA.EQ.Ø.)GOTO 239
         E = (EO-EU)*EXP(-L/EA) + EU
239      ZM = ((44.-XØ)/(XP(KK-KTOT)-XØ) -1.) * E + 1.
24Ø      IF(I1.EQ.9)AM(L,1) = (AM3(L,1)+AM3(L+1,1))*ZM*.5
         ZM = ((44.-XØ)/(XP(KK-KTOT)-XØ) -1.) * EO+ 1.
        IF(I1.EQ.9)AMØ(1) = AM1(1)*ZM
         ZM = ((44.-XØ)/(XP(KK-KTOT)-XØ) -1.) * EU+ 1.
         IF(I1.EQ.9)AM(86,1) = AM3(86,1)*ZM
3Ø65    DO 52 N=N1,N2
        IF(K-KONTR)32Ø,3Ø7,3Ø7
3Ø7     IF (KAB) 3Ø8,3Ø8,3Ø9
3Ø8     F(N)=FX(N)
        GO TO 32Ø
3Ø9     FK = Ø.1/KAB
        IF (K-KONTR-7*KAB) 31Ø,32Ø,32Ø
31Ø     IF (K-KONTR-5*KAB) 311,318,318
311     IF (K-KONTR-2*KAB) 318,315,315
315     FK = FK*2.
```

```
318   F(N) =F(N)-FA(N)*FK
320   CB(N)=F(N)
52    CONTINUE
86    DO 59 N=1,N2
      IF(1.-CD(N)*AM(86,N))355,350,355
C
C     CALCULATION OF POPULATION AT T=T+1
C
355   BAB(N) = BAB(N)*CB(N)
      TOT(N) = BAB(N)*.5*AM0(N)*CD(N)
      DO 75 L=1,86
75    TOT(N) = TOT(N) + AP(L,N)*AM(L,N)*CD(N)
      AP(86,N)=AP(85,N)*(1.-CD(N)*AM(85,N))+AP(86,N)*(1.-CD(N)*AM(86,N))
      DO 85 IL=2,85
      L=87-IL
      L1 = L-1
85    AP(L,N) = AP(L1,N)*(1.-CD(N)*AM(L1,N))
      AP(1,N) = BAB(N)*(1.-.5*CD(N)*AM0(N))
      IF (K-1970) 87,86,86
86    SBAB(N) = SBAB(N)+BAB(N)
      STOT(N) = STOT(N)+TOT(N)
87    GT(N)=GT(N)+.5*BAB(N)-.5*TOT(N)
      CBR(N) = BAB(N)/GT(N)
      CDR(N) = TOT(N)/GT(N)
      GRP4(N)=0.0
      DO 148  II=15,64
148   GRP4(N)=GRP4(N)+AP(II,N)
      TOTK(N)=BAB(N)*.5*AM0(N)*CD(N)
      DO 144  II=1,18
144   TOTK(N)=TOTK(N)+AP(II,N)*AM(II,N)*CD(N)
59    CONTINUE
      GOTO 2
350   CONTINUE
      GOTO 2
41    FORMAT (' LE,CFSTAT,CDRSTAT,TOT/BAB,P86/P85    ',3X,F5.2,
&     3(2X,F6.4),2X,F5.2)
104     FORMAT(12A2)
108   FORMAT('YEAR  TOTAL POP.  FERTIL.   BAB/POP   MORTAL.  TOT/POP',
&     '    SBAB 70   STOT 70')
109   FORMAT (19X,6F10.5)
112   FORMAT (1X,F11.2,' = ACTUAL POP',F11.2,' = CALCULATED IMMIGR.')
149   FORMAT(1X,2(F2.0,1X),F4.0,1X,F2.0,1X,5(F3.1,1X))
151   FORMAT(I4,2X,F9.1,4(3X,F7.4),2(2X,F7.1))
 169  FORMAT('GIVE POPUL.SCENARIO NUMBER, E.G. 22',/)
170   FORMAT(I2)
175   FORMAT(' SCENARIO NUMBER NOT EXISTENT')
177   FORMAT(' SPECIFY(N) EQULIBRIUM CONTROL START/SPAN,E.G. 1975/14',/)
178   FORMAT(I4,1X,I2)
179   FORMAT(' SPECIFY(N) EO,EU,EA,XL,TL E.G. 1.0/.25/10./0.0/0.0 ',/)
180   FORMAT(4(F3.1,1X),F3.1)
654   FORMAT(12A2,5X,'NORMAL RUN'//15X,'START OF CONTROL = ',
&     I4,'      TRANSITION PERIOD = ',F7.0,/)
656   FORMAT(12A2,5X,'SCENARIO RUN',I4//15X,'START OF CONTROL =
&  ',I4,'     TRANSITION PERIOD = ',F7.0,/,5X,'EO =',F4.1,5X,
&     'EU =',F4.2,5X,'EA =',F5.1,5X,'X0 =',F5.1,5X,'TL =',F5.1,/)
      END
```

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```
      SUBROUTINE SPLINE (G,AG,N1,N2)
      DIMENSION B(20),C(20),D(20),XX(20),YY(20),G(21),AG(86)
      XX(1) = 0.
      Y1 = G(1)
      YY(1) = Y1
      DO 20 L=2,20
      XX(L)=5*L-10
20    YY(L) = G(L)+YY(L-1)
      XX(2)=1.0
      G1 = YY(20)-YY(1)
      Y2 = .5*G1 + Y1
      G(21) = G(1) - G1
      IF (N1-2) 24,21,22
21    YY(20) = YY(20) + 4.*G(20)
      GO TO 24
22    DO 23 L=N1,N2
      EAG = YY(L)/Y2-1.
      YY(L) =-(EAG+1.) / (EAG-1.)
23    YY(L) = ALOG(YY(L))
24    CALL SPLIKO (B,C,D,XX,YY,N1,N2)
      L2 = 2
      L3 = 86
      IF (N1-2) 30,30,25
25    L2 = N1*5 - 9
30    IF (N2-20) 35,40,40
35    L3 = N2*5 - 9
40    DO 50 L=L3,86
50    AG(L) = G1+Y1-G(20)
      DO 55 L=1,L2
55    AG(L) = YY(1)
        L3L3=L3-1
      DO 70 L=L2,L3L3
      L1 = L+9
      IF (L-5) 60,60,65
60    L1 = L1-1
65    I=L1/5
      Q = L1-I*5
      EAG = ((D(I)*Q+C(I))*Q+B(I))*Q+YY(I)
      IF (N1-2) 70,70,66
66    EAG = EXP(EAG)
      EAG = (EAG-1.) / (EAG+1.)
      EAG = (EAG+1.)*Y2
70    AG(L) = EAG
      DO 80 L=1,85
      AG(L) = (AG(L+1)-AG(L))/G1
      IF(AG(L))81,80,80
81    AG(L)=0.0
80    CONTINUE
      AG(86) = G(20)/G1
      RETURN
      END
      SUBROUTINE SPLIKO (B,C,D,X,F,N1,N2)
      DIMENSION B(20),C(20),D(20),X(20),F(20)
      M1 = N1 + 1
      M2 = N2 - 1
      S=0
```

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```
      DO 10 I=N1,M2
      D(I) = X(I+1) - X(I)
      R = (F(I+1)-F(I)) / D(I)
      C(I) = R-S
10    S = R
      S = 0
      R = 0
      C(N1) = 0
      C(N2) = 0
      DO 20 I=M1,M2
      C(I) = C(I) + R*C(I-1)
      B(I) = (X(I-1)-X(I+1)) * 2. - R*S
      S = D(I)
20    R = S/B(I)
      DO 30 IL=M1,M2
      I=M1+M2-IL
30    C(I) = (D(I)*C(I+1) - C(I)) / B(I)
      DO 40 I=N1,M2
      S = D(I)
      R = C(I+1) - C(I)
      D(I) = R/S
      C(I) = C(I) * 3.
      B(I) = (F(I+1)-F(I)) / S - (C(I)+R) * S
40    CONTINUE
      RETURN
      END
      SUBROUTINE ALLPR(IYR,ISS,MAXI,INTER,NALL)
      NALL=5
      IF(IYR-MAXI)1,2,3
1     IF(ISS-IYR)2,2,3
2     NALL=MOD(IYR,INTER)
3     RETURN
      END
```

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