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USING THE SOFTWARE LIBRARY: AN EXAMPLE FROM MICHIGAN AGRICULTURE

On a hot, humid day in August in southern Iowa a young extension agent arrived as expected to advise a local farmer on proper feeding rations for hogs. Noticing the farmer outside working, the agent parked his car immediately downwind of the farmer's odoriferous traditional style hog lot. After about 15 minutes discussion of the weather and related events the agent asked the farmer where the hog pen was located. Due to this obvious lack of familiarity with hogs, the young agricultural county extension agent was unable to involve the farmer in extension activities. Although it may be argued that the extension agent had sufficient disciplinary knowledge to advise the farmer, this particular farmer recognized that in many situations there is no substitute for hands-on experience. The capabilities and convenience of an interactive language in an agricultural sector simulation which uses components from the software library is best demonstrated in a hands-on situation.

For this demonstration it was decided that it would be necessary to use a simplistic simulation and at the same time be general enough, comprehensive enough to include a general agricultural sector. Simplicity was required to make the simulation easily comprehended and compatible with present software components to minimize modeling and computer costs in an interactive situation. Comprehensiveness allows the interactor to see the direct and indirect results of parameter changes. At the same time, a small number of parameters reduces the complexity of policy changes and

impacts. These requirements were established to maximize the hands-on feel of the simulation and appreciation of the use of the software components in this demonstration context.

After model conceptualization has taken place, there remain two important steps which are generally overcome at a high cost in terms of resources and time before a model is operational either for running to analyze alternatives or to communicate to decision makers. The first step is from the conceptualization to a formal system model. The second is from the formal system model to a communicable set of results under various alternatives. It is highly desirable in many situations that the final result be utilized interactively by decision makers or project analysts in a conversational mode. One of the purposes of the software library is to reduce the cost of these two steps and to increase interaction capabilities with decision makers and project analysts.

Project 80&5

In 1966 the College of Agriculture and Natural Resources at MSU completed a two-year study entitled "Project 80 - An Analysis of Michigan's Rural Potential by 1890." A similar project starting in 1971 analyzed Michigan's rural potential by 1985. This was called "Project 80 & 5." The two projects were undertaken to aid long-range planning by the university, farmers, and agribusinesses.

The belief that the rural scene in Michigan was changing very rapidly led to the conclusion that old rules of thumb would not be sufficient guides to

decision making. The projects were designed to seek answers to three important questions: (1) What will rural Michigan be like in 1980 and 1985, respectively, in the natural course of events? (2) What do rural people and others concerned want it to be like in 1980 or 1985? (3) What can be done to capitalize on the opportunities, avoid impending problems, or change the natural course of events and redirect Michigan's rural economy toward the goals?

Considerable monetary and human resources went into both of these projects. Over 100 campus-based faculty members were involved at one time or another. An even larger group of rural leaders and business representatives directly concerned with the rural economy--participated in the project by reviewing papers, offering suggestions, and submitting ideas for needed programs. A series of 16 reports on Project 80 and a series of 15 reports on Project 80 & 5 were published by the Michigan State University's Agricultural Experiment Station. Copies of these research reports (37-52 and 180-194) are available from the Michigan State University Information Services, Room 10, Agriculture Hall. Project 80 & 5 was divided into three phases. Phase I was designed to establish the general environment for rural Michigan in 1985--factors important to development in rural areas but largely beyond their control--e.g., U.S. population and income, the general price level, international trade, market structures, federal farm programs, and so on. Phase II dealt more intensively with rural Michigan itself, its commodities, services, and people. Phase III is directed toward the question of what should be done to shape the future as it "ought to be." Project 80 and Project 80 & 5 were both well accepted and seemingly widely used by farm leaders, business decision makers, individuals involved in planning for research extension services

and other university and research related activities.

In terms of demonstrating the software library, Projects 80 and 80 & 5 provide a conceptual economic model. Although a formal agricultural sector model was not derived, checks for consistency were made and the necessary ground work for such a model was laid out. Readily available data combined with access to those involved in the projections aided the use of Michigan agriculture as a focus for this demonstration. The results of Project 80 and Project 80 & 5 are basically the same as the base run of the Michigan model our demonstration of the software library. However, certain values such as farm income and per capita income were not quantified specifically in Project 80 & 5. They are in the computer model basically to demonstrate this capability of the accounting component.

Michigan Production and Consumption of Agricultural Products

The state of Michigan between 1960 and 1970 increased its number of consumers by 13.4%. This was a growth rate higher than the growth rate of the United States. Michigan was one out of only two states in the north-central region that had a net in-migration in addition to its natural rate of increase. The increase in population in Michigan has been accompanied by an internal migration from farm to non-farm. Projections of the future can be utilized in making plans for transportation, government services, services to agriculture, etc. One output of this model is the level of agricultural self-sufficiency which Michigan has and can be projected to have in the future. In other words, it makes a projection of Michigan's net imports and exports of agricultural products. The model also projects farm and non-farm population. Michigan production and consumption of agricultural products are listed separately. Some projections of land utilization

and agricultural input demands for selected products from the non-farm sector are included.

The Model

Reality is infinitely complex; therefore, this model, as any model must, extracts from reality those relationships which are considered to be determining factors of the information sought. The level of accuracy in any model should be sufficient to serve the purposes to which the model is put. The purpose of this demonstration is to demonstrate the possibilities of using an easily accessible software library to develop a simulation model. The generalizations utilized in this model are very broad. As more components are added to the software library, they will facilitate the construction of a much more complex and usuable simulation model. In this particular situation easy access to a recursive linear programming component would have facilitated a much more realistic model. However, design of such a component is not within the scope of this demonstration.

A model is no better than its conceptual and mathematical base. Therefore, it is prescribed that researchers doing simulation work for purposes other than the demonstration of software library components use the components of the software library as tools and not as limiting factors. In other words, the model should be designed by the researcher; then, the relevant components from the software library may be used for the purposes of simplifying the programming step of the model building process.

Concentration of attention in the design of the Michigan demonstration model was centered on the level of self-sufficiency in 16 different crop

and livestock activities presently in production in the state of Michigan. In Project 80 and Project 80 & 5 human consumption of agricultural products were made. Projections were also made of production of agricultural products in the state of Michigan. Although no self-sufficiency ratios were developed in these projects, it was quite simple to hook the two together in a simulation situation using the accounting component of the software library.

The Michigan production and consumption of agricultural products model utilizes seven (7) components of the software library. These are: two demongraphic components, two table components, two delay components, and an accounting model. The major subsectors, flows and output of the economic conceptual model are shown in Figure 1. Simplistically this model can be described starting with the population and migration model and progressing along the product flow arrows.

The population and migration model starts with 1970 population of Michigan in two groupings: farm human population and non-farm human population. Migration to and from both populations are assumed to be constant in absolute numbers, and equal to the average age-sex specific migration rates between 1960 and 1970. Age sex specific mortality rates are considered to be constant and equal to the 1970 rate. Fertility rates include the actual 1970 age specific fertility rates and the actual 1971 age specific fertility rates. Fertility rates after 1971 are assumed to proportionately decrease to values consistent with zero population growth by 1990.

The land allocation component separates land into two categories: non-agricultural demand for land and agricultural land. Total land in the state

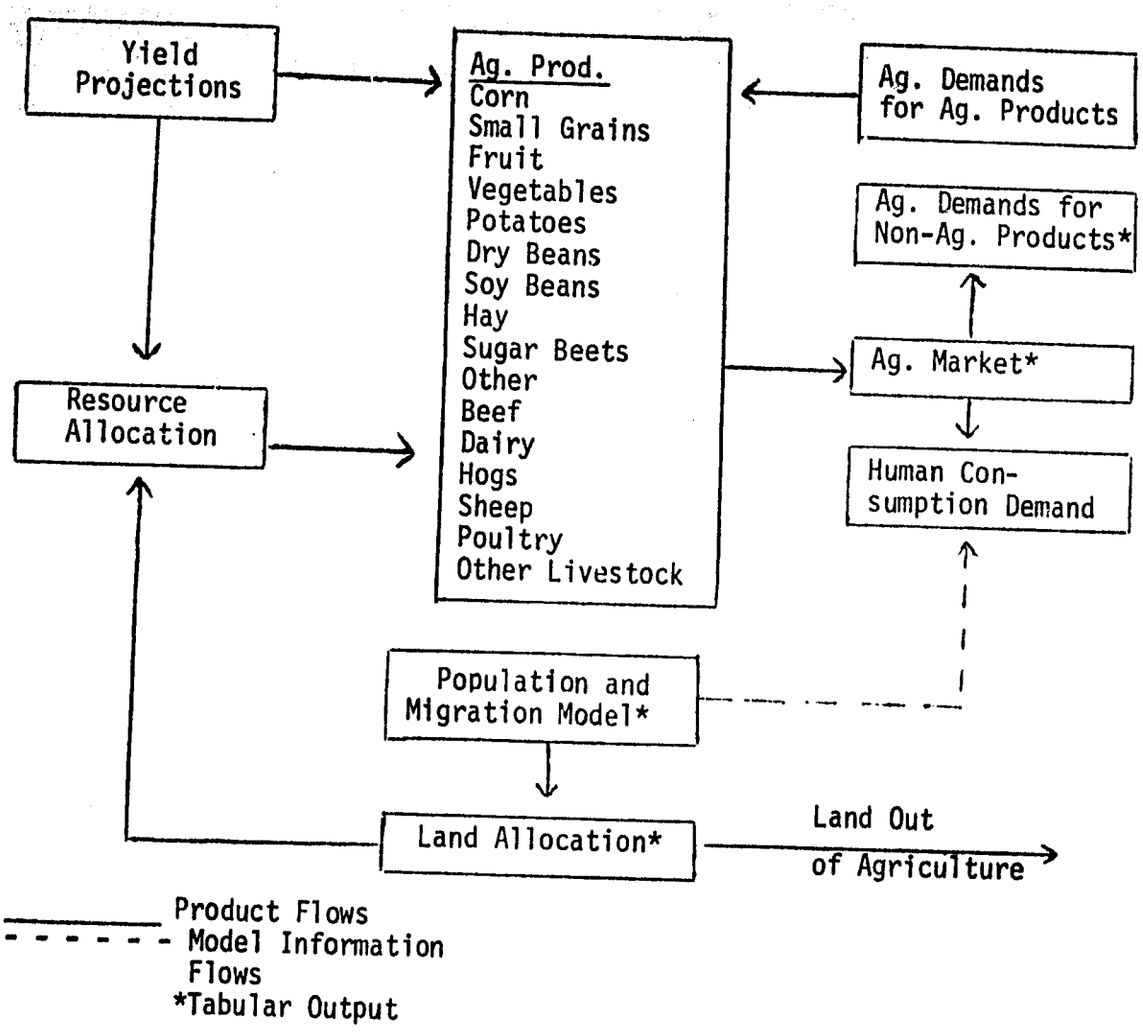

Figure 1: Major subsectors, flows and output of the economic conceptual model.

of Michigan is 36,492,000 acres. The nonagricultural demand for land is assumed to be 3.00 acres per person in the nonfarm population and 2.75 acres per person in the farm population. Conceptually, this demand for land includes demand for urban residences, forests and recreational lands, public forests, parks and recreation area, wildlife areas, private forests and recreation land, highways and roads, other transportation areas, national defense areas, industrial and service areas, and miscellaneous and idle nonagricultural demands for land.

Nonagricultural demand for land is subtracted from total land to derive agricultural land. It is felt that the present state of reality is best reflected by allocating nonagricultural land on a demand basis (that implies elacticity of demand approximately zero) with agriculture--geting the residual.

The resource allocation model estimates livestock numbers and proportion of agricultural land in each crop category. Crop and livestock categories are listed in the agricultural production component block in Figure 1.

Livestock numbers for Michigan in 1980 and 1985 are drawn directly from Projects 80 and 80 & 5. They are in the model as a given exogenous conditioning with the exception of the dairy cow population which uses another demographic component from the software library. This component uses the 1970 population of dairy cows and excgenously determined fertility, mortality, and cull rates. Cull rates include not only culls from dairy herds but also the ext of dairy herds from Michigan through sales either to the slaughter industry or to other states' dairy herds. These parameters were estimated to coincide

with the dairy specialists' projection for 1985.

Output from the land allocation component, Michigan agricultural statistics, and crop specialists projections to 1980 and 1985 combine to give the proportion of agricultural land in each crop category.

The yield projections component serves two functions for the overall model. First, it is utilized directly in the model to determine total production given certain acreage allotments to each agricultural product. Second, yield projections are utilized by the resource allocation component of the model. However, as presently conceived, the quantities from yield projections are not used directly in a programming methodology within the resource allocation component but are taken into consideration by those designing the resource allocation component parameters. The yield projection component consists of a group of equations where yield is a function of time.

The agricultural production component consists of a series of equations indicating the demand for both agricultural and nonagricultural inputs as a function of the allocation of land to each particular crop and numbers of livestock raised. For instance, one dairy cow would require X1 quantity of corn, X2 quantity of wheat, X3 quantity of labor, X4 quantity of capital resources, etc. Yield projections would be multiplied by resource allocation to determine agricultural production going to the agricultural market. All parameters in each of these equations of agricultural production are functions of time.

The agricultural market component is an accounting component which calculates net imports and exports of agricultural products. It uses as data,

agricultural production minus agricultural demand minus human consumption demand.

The agricultural demand for agricultural products parameters are decided by summing up input demands for agricultural products from the agricultural production component.

The agricultural demand for nonagriculturally produced inputs component is a summation of all inputs necessary for agricultural production not included in the component immediately above.

The human consumption demand component utilizes the population and a linear interpolation of Projects 80 and 80 & 5's projections of food consumption and demand for horse services by individuals. It is not necessary for agricultural production to be equal to agricultural demands for agricultural products plus human consumption demand because the residual, either positive or negative, is considered to be a net import or export figure for the particular product involved.

Formal System Model

The economic conceptual model presented above can be regarded as almost too simplistic to be considered a system due to the majority of the model being exogenous in terms of most of the relevant numbers. However, at the risk of the wrath of the systems scientists, we shall consider it conceivable as a system. The formal system model derived is pictured in Figure 2. The formal system model consists of six components. The characteristics of the human population component is basically the same as described in the economic conceptual model. The livestock population component and the land allocation component were, in the economic conceptual

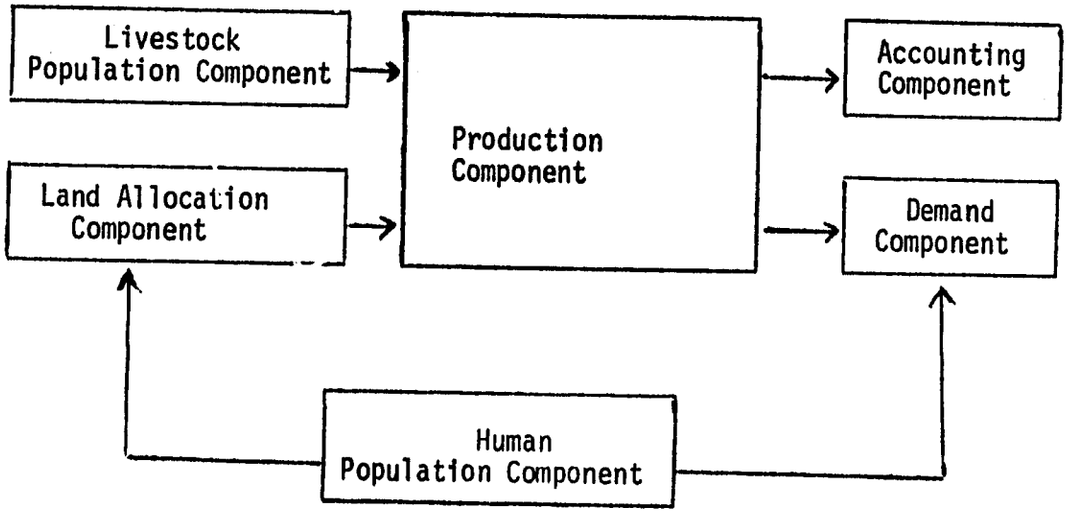

Figure 2: Data Information Flows in Simulation Model

model, combined into one component. Because of the basic difference in their place in the agricultural sector system, it was decided that two components were more appropriate in terms of a formal system model. The production component in the formal system includes both the yield projections and the conceptual input-output table of the agricultural production component. Using land allocation from that component, the production component computes agricultural production.

Due to similarity of utilization and derivation of demands and supply quantities, the agricultural demands for agricultural products, agricultural demands for non-agricultural products, and the human consumption demand components are all combined in the system model into one component called the demand component. This component computes a summation of the inputs demanded in the agricultural production component; per capita demand for each agricultural product times the population in Michigan; and differences between supplies and demands, arriving at net import-export balances.

The accounting component in the formal system model has its origin directly from the software library. However, the simplicity of our model was unable to show the large versitility of the software accounting component. Calculations made in this particular model include: expenditures on inputs, gross income, farm consumption, cash income, total profits, net profit, value added, taxes, and per unit profits both net and total.

The formal system model, in combination with the software library components included to facilitate programming, was presented to a programmer in combination with a text and decision-making process for the interactive language. Output options were set up for the purpose of conciseness that interactors with the demonstration model may more rapidly get their hands on the data they are interested in observing.

Policy Experimentation Options

Policy experiments with the formal system model are categorized by component and involve changing parameter values. Parameters which may be so accessed via the conversation packages are:

1. For the human population component:
   a. The proportional rate of decrease of fertility rates.
   b. Changes in the off-farm migration rates by age group over time.

2. For the livestock population component:
   a. Slaughter rates in 1985
   b. Dairy cow fertility rates by age group
   c. Dairy cow cull rates by age group

3. For the land allocation component:
   a. Per capita demand for non-farm land from the farm and non-farm sectors.
   b. Proportional crop land allocations

4. For the production component:
   a. Commodity yields
   b. Unit input requirements by commodity in 1970
   c. Rates of change of unit input requirements by commodi

5. For the demand component:
   a. Per capita consumption demand by commodity

6. For the accounting component:
   a. Farm-gate commodity prices
   b. Net revenue tax rates by commodity

There are also several output options available. The parameters which can be changed are:

1. The points in time for which printing occur
2. Those components for which a detailed printout is required

```
      SUBROUTINE MICMOD
      COMMON /LINK/   KNDPRT, NPRT, TPRT(6), RCFRTR, PMRFB(19,2),
     +                VPMRF1(4), VPMRF2(4), VPMRF3(4), VPMRF4(4),
     +                ARGMF1(4), ARGMF2(4), ARGMF3(4), ARGMF4(4),
     +                POPL70(7), POPL85(7), FERTDC(3), CULLR(3),
     +                VPCDLF(4), VPCDLN(4), VPCL(3,9), VYLD(3,17),
     +                RINP70(17,12), RRINP(17,12), VPCDEM(3,17),
     +                PRP(17), RTAX(17), PLNF
      COMMON /PRINTC/ IPRT,NPVAR,VAROUT(75,7), POPMI, TPOPF,TYGA,
     +                VALAD, AGLND, AGLNDC, TYGAL, TPDEM, TPFT,
     +                CBRT, CDRT, GFR, FERTR(19), TFERT, TPOPG1,
     +                TPOPG2, TPOPG3, TPOPG4, PPOPG1, PPOPG2, PPOPG3,
     +                DEPRAT, FPOPG1, FPOPG2, FPOPG3, FPOPG4, PFPG1,
     +                PFPG2, PFPG3, FDPRAT, PCNI, AGLNPC, POPLS(7),
     +                GYPU(17), COST(17), PFTPU(17), POPDC(3), AGLNDL,
     +                CRPLND(10), AGPROD(17), COMAID(17), CONDEM(17),
     +                SUPDEM(17), NETEXP, TPFTN, COSLAB, FARMY,
     +                YPCAP, XLABS, TDEM(12)
      COMMON / MICH/   YEAR, T, DT, NENT, NCR, NL, NINP, TPOPNF, TPFL,
     +                TPNFL, CULLDC, DEMNFL, TYC, ANLND(7), YC(17),
     +                EXPIMP(17), YGA(17), PFT(17), VALADC(10),
     +                VALADL(7), DEMINP(17,12), FRMLAB, POPF(19,2),
     +                POPNF(19,2), PRINP(12)
      DATA DUP,DT / 15., .5 /
      DATA DETPRT,SELPRT / 0., 1. /
      DATA NENT,NCR,NL,NINP / 17, 10, 7, 12 /

         INITIALIZE MODEL VARIABLES

      POPF(1,1) = 2689.
      POPF(2,1) = 10754.
      POPF(3,1) = 19431.
      POPF(4,1) = 23848.
      POPF(5,1) = 20584.
      POPF(6,1) = 9367.
      POPF(7,1) = 9223.
      POPF(8,1) = 9761.
      POPF(9,1) = 10451.
      POPF(10,1) = 12022.
      POPF(11,1) = 13073.
      POPF(12,1) = 12560.
      POPF(13,1) = 11159.
      POPF(14,1) = 8948.
      POPF(15,1) = 6669.
      POPF(16,1) = 4997.
      POPF(17,1) = 3475.
      POPF(18,1) = 2125.
      POPF(19,1) = 1446.
      POPF(1,2) = 2982.
      POPF(2,2) = 11927.
      POPF(3,2) = 20676.
      POPF(4,2) = 25761.
      POPF(5,2) = 22613.
      POPF(6,2) = 10266.
      POPF(7,2) = 8783.
      POPF(8,2) = 9423.
      POPF(9,2) = 9991.
      POPF(10,2) = 11371.
      POPF(11,2) = 12467.
      POPF(12,2) = 13137.
      POPF(13,2) = 12729.
```

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POPF(14,2) = 10159.
POPF(15,2) = 7629.
POPF(16,2) = 5306.
POPF(17,2) = 3775.
POPF(18,2) = 2055.
POPF(19,2) = 1259.
POPNF(1,1) = 76928.
POPNF(2,1) = 303997.
POPNF(3,1) = 433121.
POPNF(4,1) = 456573.
POPNF(5,1) = 415620.
POPNF(6,1) = 364538.
POPNF(7,1) = 290872.
POPNF(8,1) = 239514.
POPNF(9,1) = 233128.
POPNF(10,1) = 256874.
POPNF(11,1) = 258334.
POPNF(12,1) = 233660.
POPNF(13,1) = 199766.
POPNF(14,1) = 172239.
POPNF(15,1) = 133671.
POPNF(16,1) = 109860.
POPNF(17,1) = 81195.
POPNF(18,1) = 49646.
POPNF(19,1) = 33419.
POPNF(1,2) = 79777.
POPNF(2,2) = 315410.
POPNF(3,2) = 450589.
POPNF(4,2) = 473083.
POPNF(5,2) = 413807.
POPNF(6,2) = 318571.
POPNF(7,2) = 284720.
POPNF(8,2) = 230067.
POPNF(9,2) = 220502.
POPNF(10,2) = 247983.
POPNF(11,2) = 245347.
POPNF(12,2) = 219430.
POPNF(13,2) = 188599.
POPNF(14,2) = 151925.
POPNF(15,2) = 115609.
POPNF(16,2) = 83982.
POPNF(17,2) = 59114.
POPNF(18,2) = 31465.
POPNF(19,2) = 18360.
POPDC(1) = 291000.
POPDC(2) = 248700.
POPDC(3) = 221300.
PRINP(11) = 3.00
PRINP(12) = 1.50

    INITIALIZE RUN PARAMETERS

NITER = DUR/DT + 1.000000
T = -DT
YEAR = T + 1970.
IPRT = 0
IF(SELPRT .GT. 0.) CALL PRINTS
IF(SELPRT .EQ. 0.) IPRT = 1.

    BEGIN TIME LOOP
```

```
      DO 250 ITER=1,NITER
      T = T + DT
      YEAR = YEAR + DT
      CALL POPULN
      CALL LVSPOP
      CALL LAND
      CALL PRODCN
      CALL DEMAND
      CALL ACCENT
      IF(YEAR .LT. TPRT(IPRT)) GO TO 250
C
C         FILL SELECTED OUTPUT TABLE
C
      IF(SELPRT .GT. 0.) CALL PRINTS
      IF(IPRT .GT. NPRT) GO TO 260
      IF(DETPRT .LT. 1.) GO TO 250
C
C         PRINT DETAILED OUTPUT
C
      IPRT = IPRT + 1
      PRINT900,T,POPMI,TPOPF,TPOPNF,POPDC
      PRINT904,VALAD,TPFT,TYGA,TYC,DEMNFL,AGLND,XLABS
      PRINT906,AGLNDL,AGLNDC,PCNI
      PRINT908,POPLS
      PRINT912,ANLND
      PRINT916,VALADL
      PRINT920,CRPLND
      PRINT924,VALADC
      PRINT928,(AGPROD(IENT),COMAID(IENT),CONDEM(IENT),EXPIMP(IENT),
     +          YGA(IENT),YC(IENT),PFT(IENT),IENT=1,NENT)
      PRINT932,PFTPU
      PRINT936,SUPDEM
      IF(IPRT .GT. NPRT) GO TO 260
250   CONTINUE
260   IF(SELPRT .EQ. 0.) RETURN
C
C         PRINT SELECTED OUTPUT TABLE
C
      IF(NPRT .LT. 5) 270,290

270   PRINT960,(TPRT(I),I=1,NPRT)
      DO 280 I=1,NPVAR
      PRINT965,(VAROUT(I,J),J=1,IPRT)
280   CONTINUE
      GO TO 310
290   PRINT950,(TPRT(I),I=1,NPRT)
      DO 300 I=1,NPVAR
      PRINT955,(VAROUT(I,J),J=1,IPRT)
300   CONTINUE
310   CONTINUE
C
C         FORMAT STATEMENTS
C
900   FORMAT(2H1T,9X,5HPOPMI,5X,5HTPOPF,5X,6HTPOPNF,4X,5HPOPDC/1H
     +       F5.2,5X,6E10.4)
  4   FORMAT(6HOVALAD,5X,4HTPFT,6X,4HTYGA,6X,3HTYC,7X,6HDEMNFL,4X,
     +       5HAGLND,5X,5HXLABS/1H ,7E10.4)
904   FORMAT(1H0,4X*AGLNDL*,4X*AGLNDC*4X,*PCNI*/1H ,3E10.4)
908   FORMAT(6HOPOPLS/1H ,7E10.4)
912   FORMAT(6HOANLND/1H ,7E10.4)
916   FORMAT(7HOVALADL/1H ,7E10.4)
```

```
920   FORMAT(7HOCRPLND/1H ,7E10.4/1H ,3E10.4)
924   FORMAT(7HOVALADC/1H ,7E10.4/1H ,3E10.4)
928   FORMAT(7HOAGPROD,4X,5HCOMAID,4X,6HCONDEM,4X,6HEXPIMP,4X,3HYGA,
     +       7X,2HYC,8X,3HPFT/17(1H ,7E10.4/))
9(    FORMAT(6HOPFTPU/1H ,7E10.4/2(1H ,7E10.4/))
93(   FORMAT(7HOSUPDEM/3(1H ,7E10.4/))
950   FORMAT(*1*12X,6(F5.0,5X)/)
955   FORMAT(* *A10,6E10.4)
960   FORMAT(*1*18X,4(F5.0,10X))
965   FORMAT(* *A10,4F15.2)
      END
```

```
      SUBROUTINE POPULN
      COMMON /LINK/   KNOPRT, NPRT, TPRT(6), RCFRTR, PMRFB(19,2),
     +                VPMRF1(4), VPMRF2(4), VPMRF3(4), VPMRF4(4),
     +                ARGMF1(4), ARGMF2(4), ARGMF3(4), ARGMF4(4),
     +                POPL70(7), POPL85(7), FERTDC(3), CULLR(3),
     +                VPCDLF(4), VPCDLN(4), VPCL(3,9), VYLD(3,17),
     +                RINP70(17,12), RRINP(17,12), VPCDEM(3,17),
     +                PRP(17), RTAX(17), PLNF
      COMMON /PRINTC/ IPRT,NPVAR, VAROUT(75,7), POPMI, TPOPF, TYGA,
     +                VALAD, AGLND, AGLNDC, TYGAL, TPDEM, TPFT,
     +                CBRT, CDRT, GFR, FERTR(19), TFERT, TPOPG1,
     +                TPOPG2, TPOPG3, TPOPG4, PPOPG1, PPOPG2, PPOPG3,
     +                DEPRAT, FPOPG1, FPOPG2, FPOPG3, FPOPG4, PFPG1,
     +                PFPG2, PFPG3, FDPRAT, PCNI, AGLNPC, POPLS(7),
     +                GYPU(17), COST(17), PFTPU(17), POPDC(3), AGLNDL,
     +                CRPLND(10), AGPROD(17), COMAID(17), CONDEM(17),
     +                SUPDEM(17), NETEXP, TPFTN, COSLAB, FARMY,
     +                YPCAP, XLABS, TDEM(12)
      COMMON / MICH/   YEAR, T, DT, NENT, NCR, NL, NINP, TPOPNF, TPFL,
     +                TPNFL, CULLDC, DEMNFL, TYC, ANLND(7), YC(17),
     +                EXPIMP(17), YGA(17), PFT(17), VALADC(10),
     +                VALADL(7), DEMINP(17,12), FRMLAB, POPF(19,2),
     +                POPNF(19,2), PRINP(12)
      DIMENSION ARF(19,2), ARNF(19,2), BTHF(19,2), BTHNF(19,2)
      DIMENSION CLEN(19,2), DR(19,2), DTHF(19,2), DTHNF(19,2)
      DIMENSION EQMD(19,2), FRTR70(19), FRTR71(19), PLRF(19,2)
      DIMENSION PLRNF(19,2), PMRF(19,2), PMRNF(19,2)
      DIMENSION POPSF(2), POPSNF(2), RTPF(1), RTPNF(1), TMRIM(19,2)
      DATA FRTR70 /      0.,      0.,      0., .001018, .068246,
     +            .176260, .154191, .076260, .032468, .008259,
     +            .000450,    8*0. /
      DATA FRTR71 /      0.,      0.,      0., .000931, .061218,
     +            .160023, .139836, .068544, .028487, .006344,
     +            .000412,    8*0. /
      DATA DR / .003350, .000376, .000263, .000431, .000722, .000760,
     +          .000860, .001402, .002284, .003434, .005052, .007536,
     +          .010949, .016496, .025183, .038616, .059220, .017224,
     +          .030912,
     +          .004212, .000477, .000450, .000929, .001962, .002109,
     +          .001903, .002491, .003806, .005875, .008744, .013603,
     +          .021369, .031888, .044781, .061792, .083534, .051172,
     +          .037175 /
      DATA TMRIM /   301.,  1206.,  2734.,   426.,   167.,   956.,
     +            1453.,  1010.,   120.,   -42.,  -132.,  -229.,
     +            -512., -1007., -1348.,  -779.,  -110.,  -133.,
     +              56.,
     +             278.,  1113.,  2728.,   322., -1402., -4262.,
     +            2554.,  3362.,   503.,   163.,   104.,   -31.,
     +            -173.,  -712., -1205.,  -981.,  -352.,  -168.,
     +               2. /
      DATA EQMD / 0., 0., 0., .1, .2, .2, .2, .2, .2, .2, .2, .2, .2,
     +            .2, .1, .1, 0., 0., 0.,
     +            0., 0., 0., .2, .5, 1., 1., 1., 1., 1., 1., 1., 1.,
     +            .6, .4, .2, .1, .1, .1 /
      DATA CLEN / 1., 4., 16*5., 15., 1., 4., 16*5., 15. /
      DATA DELNFL,KNFL,DELFL,KFL / 10., 1, 10., 1 /
      DATA NOBTH,PBF,RCFRTR / 0, .4865, .0092 /
      DATA NC,NSEX / 19, 2 /
      DATA KMF / 4 /
      IF(T .GT. 0.) 5,9
      CALL DEL(TPOPNF,TPNFL,RTPNF,DELNFL,DT,KNFL)
```

```
      CALL DEL(TPOPF,TPFL,RTPF,DELFL,DT,KFL)
C
C         HUMAN POPULATION
C
      CALL DEMOGD(POPNF,POPSNF,TPOPNF,SRNF,CLEN,ARNF,DR,CDRNF,DTHNF,
     +            TDTHNF,NOBTH,PBF,FERTR,CBRNF,BTHNF,TBTHNF,PLRNF,
     +            PMRNF,TMRNF,PGRNNF,PGRTNF,NC,NSEX,DT,T,1)
      CALL DEMOGD(POPF,POPSF,TPOPF,SRF,CLEN,ARF,DR,CDRF,DTHF,TDTHF,
     +           NOBTH,PBF,FERTR,CBRF,BTHF,TBTHF,PLRF,PMRF,TMRF,PGRNF,
     +            PGRTF,NC,NSEX,DT,T,1)
      IF(T .EQ. 0.) 10,15
10    TPNFL = 7384028.*EXP(-1.)*(1.+(EXP(1.1336)-1.)/1.1336)
      TPFL = 440937.*EXP(-1.)*(1.+(EXP(1.1336)-1.)/1.1336)
      DO 12 K=1,KNFL
      RTPNF(K) = TPNFL
12    CONTINUE
      DO 13 K=1,KFL
      RTPF(K) = TPFL
13    CONTINUE
C
C         FERTILITY RATES
C
15    IF(T .LE. 1.) 20,30
20    DO 25 IC=1,NC
      FERTR(IC) = FRTR70(IC) + T*(FRTR71(IC)-FRTR70(IC))
25    CONTINUE
      GO TO 45
30    IF(T .LE. 20.) 35,45
35    DO 40 IC=1,NC
      FERTR(IC) = FERTR(IC)*(1.-DT*RCFRTR)
      CONTINUE
C
C         MIGRATION RATES
C
45    PPMRF1 = TABULS(VPMRF1,KMF,ARGMF1,YEAR)
      PPMRF2 = TABULS(VPMRF2,KMF,ARGMF2,YEAR)
      PPMRF3 = TABULS(VPMRF3,KMF,ARGMF3,YEAR)
      PPMRF4 = TABULS(VPMRF4,KMF,ARGMF4,YEAR)
      DO 75 JS=1,NSEX
      DO 50 IC=1,4
      PMRF(IC,JS) = PPMRF1*PMRFB(IC,JS)
50    CONTINUE
      DO 55 IC=5,9
      PMRF(IC,JS) = PPMRF2*PMRFB(IC,JS)
55    CONTINUE
      DO 60 IC=10,13
      PMRF(IC,JS) = PPMRF3*PMRFB(IC,JS)
60    CONTINUE
      DO 65 IC=14,19
      PMRF(IC,JS) = PPMRF4*PMRFB(IC,JS)
65    CONTINUE
      DO 70 IC=1,NC
      PMRNF(IC,JS) = -(PMRF(IC,JS)*POPF(IC,JS)+TMRIM(IC,JS))/
     +               POPNF(IC,JS)
70    CONTINUE
      CONTINUE
C
C         BIRTHS, DEATHS, MIGRATION
C
      CALL DEMOGD(POPNF,POPSNF,TPOPNF,SRNF,CLEN,ARNF,DR,CDRNF,DTHNF,
     +            TDTHNF,NOBTH,PBF,FERTR,CBRNF,BTHNF,TBTHNF,PLRNF,
```

```
     +                PMRNF,TMRNF,PGRNNF,PGRTNF,NC,NSEX,DT,T,2)
      CALL DEMOGD(POPF,POPSF,TPOPF,SRF,CLEN,ARF,DR,CDRF,DTHF,TDTHF,
     +            NOBTH,PBF,FERTR,CBRF,BTHF,TBTHF,PLRF,PMRF,TMRF,PGRNF,
     +             PGRTF,NC,NSEX,DT,T,2)
      FRMLAB = 0.
      DO 85 IC=1,NC
      DO 80 JS=1,NSEX
      FRMLAB = FRMLAB + 1760.*EQMD(IC,JS)*POPF(IC,JS)
80    CONTINUE
85    CONTINUE
      POPMI = TPOPNF + TPOPF
      IF(KNOPRT .NE. 1 .OR. YEAR .NE. TPRT(IPRT))RETUR
C
C         STATISTICS FOR PRINTING
C
      CBRT = 1000.*(CBRF*TPOPF+CBRNF*TPOPNF)/POPMI
      CDRT = 1000.*(CDRF*TPOPF+CDRNF*TPOPNF)/POPMI
      TPOPG1 = 0.
      TPOPG2 = 0.
      TPOPG3 = 0.
      TPOPG4 = 0.
      FPOPG1 = 0.
      FPOPG2 = 0.
      FPOPG3 = 0.
      FPOPG4 = 0.
      GFERTR = 0.
      GPOP = 0.
      TFERT = 0.
      DO 100 IC=1,4
      FPOPG1 = FPOPG1 + POPF(IC,1) + POPF(IC,2)
      TPOPG1 = TPOPG1 + POPF(IC,1) + POPF(IC,2) + POPNF(IC,1) +
     +         POPNF(IC,2)
100   CONTINUE
      DO 110 IC=5,10
      FPOPG2 = FPOPG2 + POPF(IC,1) + POPF(IC,2)
      TPOPG2 = TPOPG2 + POPF(IC,1) + POPF(IC,2) + POPNF(IC,1) +
     +         POPNF(IC,2)
      GFERTR = GFERTR + FERTR(IC)*(POPF(IC,1)+POPNF(IC,1))
      GPOP = GPOP + POPF(IC,1) + POPNF(IC,1)
110   CONTINUE
      DO 120 IC=11,14
      FPOPG3 = FPOPG3 + POPF(IC,1) + POPF(IC,2)
      TPOPG3 = TPOPG3 + POPF(IC,1) + POPF(IC,2) + POPNF(IC,1) +
     +         POPNF(IC,2)
120   CONTINUE
      DO 130 IC=15,19
      FPOPG4 = FPOPG4 + POPF(IC,1) + POPF(IC,2)
      TPOPG4 = TPOPG4 + POPF(IC,1) + POPF(IC,2) + POPNF(IC,1) +
     +         POPNF(IC,2)
130   CONTINUE
      DO 140 IC=4,11
      TFERT = TFERT + 5.*FERTR(IC)
140   CONTINUE
      GFR = 1000.*GFERTR/GPOP
      PPOPG1 = 100.*TPOPG1/POPMI
      PPOPG2 = 100.*(TPOPG2+TPOPG3)/POPMI
      PPOPG3 = 100.*TPOPG4/POPMI
      DEPRAT = (PPOPG1+PPOPG3)/PPOPG2
      PFPG1 = 100.*FPOPG1/TPOPF
      PFPG2 = 100.*(FPOPG2+FPOPG3)/TPOPF
      PFPG3 = 100.*FPOPG4/TPOPF
```

```
FDPRAT = (PFPG1+PFPG3)/PFPG2
RETURN
END
```

```
      SUBROUTINE LVSPOP
      COMMON /LINK/    KNOPRT, NPRT, TPRT(6), RCFRTR, PMRFB(19,2),
     +                 VPMRF1(4), VPMRF2(4), VPMRF3(4), VPMRF4(4),
     +                 ARGMF1(4), ARGMF2(4), ARGMF3(4), ARGMF4(4),
     +                 POPL70(7), POPL85(7), FERTDC(3), CULLR(3),
     +                 VPCDLF(4), VPCDLN(4), VPCL(3,9), VYLD(3,17),
     +                 RINP70(17,12), RRINP(17,12), VPCDEM(3,17),
     +                 PRP(17), RTAX(17), PLNF
      COMMON /PRINTC/ IPRT,NPVAR, VAROUT(75,7), POPMI, TPOPF, TYGA,
     +                 VALAD, AGLND, AGLNDC, TYGAL, TPDEM, TPFT,
     +                 CBRT, CDRT, GFR, FERTR(19), TFERT, TPOPG1,
     +                 TPOPG2, TPOPG3, TPOPG4, PPOPG1, PPOPG2, PPOPG3,
     +                 DEPRAT, FPOPG1, FPOPG2, FPOPG3, FPOPG4, PFPG1,
     +                 PFPG2, PFPG3, FDPRAT, PCNI, AGLNPC, PO LS(7),
     +                 GYPU(17), COST(17), PFTPU(17), POPDC(3), AGLNDL,
     +                 CRPLND(10), AGPROD(17), COMAID(17), CONDEM(17),
     +                 SUPDEM(17), NETEXP, TPFTN, COSLAB, FARMY,
     +                 YPCAP, XLABS, TDEM(12)
      COMMON / MICH/    YEAR, T, DT, NENT, NCR, NL, NINP, TPOPNF, TPFL,
     +                 TPNFL, CULLDC, DEMNFL, TYC, ANLND(7), YC(17),
     +                 EXPIMP(17), YGA(17), PFT(17), VALADC(10),
     +                 VALADL(7), DEMINP(17,12), FRMLAB, POPF(19,2),
     +                 POPNF(19,2), PRINP(12)
      DIMENSION BTHDC(2), DELDC(3), DELPDC(3), DRDC(3), DTHDC(3)
      DIMENSION KCDC(3), PLRDC(3), ROAVDC(3), ROUTDC(3), RPDC(10,3)
      DATA DRDC / .010, .020, .02 /
      DATA NOBTHC,PBFDC / 0, .5 /
      DATA DELDC / 2., 3., 4.5 /
      DATA KCDC / 10, 6, 3 /
      DATA NKDC,NCDC,NSEXDC / 10, 3, 1 /
C
C         DAIRY HERD POPULATION
C
      CALL DEMOGC(POPDC,ROUTDC,ROAVDC,RPDC,DELDC,DELPDC,KCDC,POPSDC,
     +            TPOPDC,SRDC,DRDC,CDRDC,DTHDC,TDTHDC,NOBTHC,PBFDC,
     +            FERTDC,CBRDC,BTHDC,TBTHDC,CULLDC,CULLR,PLRDC,PGRNDC,
     +             PGRTDC, NKDC,NCDC,NSEXDC,DT,T,0)
C
C         OTHER LIVESTOCK POPULATIONS
C
      POPLS(1) = POPL70(1) + (POPL85(1)-POPL70(1))*T/15.
      POPLS(2) = POPDC(2) + POPDC(3)
      DO 30 IL=3,NL
      POPLS(IL) = POPL70(IL) + (POPL85(IL)-POPL70(IL))*T/15.
30    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LAND
      COMMON /LINK/    KNDPRT, NPRT, TPRT(6), RCFRTR, PMRFB(19,2),
     +                 VPMRF1(4), VPMRF2(4), VPMRF3(4), VPMRF4(4),
     +                 ARGMF1(4), ARGMF2(4), ARGMF3(4), ARGMF4(4),
     +                 POPL70(7), POPL85(7), FERTDC(3), CULLR(3),
     +                 VPCDLF(4), VPCDLN(4), VPCL(3,9), VYLD(3,17),
     +                 RINP70(17,12), RRINP(17,12), VPCDEM(3,17),
     +                 PRP(17), RTAX(17), PLNF
      COMMON /PRINTC/ IPRT,NPVAR, VAROUT(75,7), POPMI, TPOPF, TYGA,
     +                 VALAD, AGLND, AGLNDC, TYGAL, TPDEM, TPFT,
     +                 CBRT, CORT, GFR, FERTR(19), TFERT, TPOPG1,
     +                 TPOPG2, TPOPG3, TPOPG4, PPOPG1, PPOPG2, PPOPG3,
     +                 DEPRAT, FPOPG1, FPOPG2, FPOPG3, FPOPG4, PFPG1,
     +                 PFPG2, PFPG3, FDPRAT, PCNI, AGLNPC, POPLS(7),
     +                 GYPU(17), COST(17), PFTPU(17), POPDC(3), AGLNDL,
     +                 CRPLND(10), AGPROD(17), COMAID(17), CONDEM(17),
     +                 SUPDEM(17), NETEXP, TPFTN, COSLAB, FARMY,
     +                 YPCAP, XLABS, TDEM(12)
      COMMON / MICH/    YEAR, T, DT, NENT, NCR, NL, NINP, TPOPNF, TPFL,
     +                 TPNFL, CULLDC, DEMNFL, TYC, ANLND(7), YC(17),
     +                 EXPIMP(17), YGA(17), PFT(17), VALADC(10),
     +                 VALADL(7), DEMINP(17,12), FRMLAB, POPF(19,2),
     +                 POPNF(19,2), PRINP(12)
      DIMENSION ARGCL(3), PCL(10), PHLR(7), PHLR70(7), RPHLR(7)
      DATA KLF,SLF,DLF,KLN,SLN,DLN / 4, 1970., 5., 4, 1970., 5. /
      DATA PHLR70 / 2., .01, .001,  .3, .00001, .0001, 2. /
      DATA RPHLR / -.1, 0., 0., 0., 0., 0., -.067 /
      DATA ARGCL / 1970., 1980., 1985. /
      DATA KCL / 3 /
      DATA TLND / 36492000. /

          FARM AND NONFARM LAND
C
      PCDNLF = TABELS(VPCDLF,KLF,SLF,DLF,YEAR)
      PCDNLN = TABELS(VPCDLN,KLN,SLN,DLN,YEAR)
      DEMNFL = PCDNLF*TPFL + PCDNLN*TPNFL
      IF(DEMNFL .GT. PLNF*TLND) DEMNFL = PLNF*TLND
      AGLND = TLND - DEMNFL
      AGLNPC = AGLND/TPOPF
C
C         LIVESTOCK LAND
C
      DO 20 IL=1,NL
      PHLR(IL) = PHLR70(IL) + RPHLR(IL)*T
20    CONTINUE
      ANLND(1) = PHLR(1)*POPLS(1)
      ANLND(2) = PHLR(2)*(POPLS(2)+POPDC(1))
      AGLNDL = ANLND(1) + ANLND(2)
      DO 30 IL=3,NL
      ANLND(IL) = PHLR(IL)*POPLS(IL)
      AGLNDL = AGLNDL + ANLND(IL)
30    CONTINUE
      IF(AGLNDL .LE. AGLND) GO TO 45
      DO 40 IL=1,NL
      ANLND(IL) = ANLND(IL)*AGLND/AGLNDL
 0    CONTINUE
      AGLNDL = AGLND
C
C         CROP LAND
C
45    AGLNDC = AGLND - AGLNDL
```

```
TPCL = 0.
DO 50 ICR=1,9
PCL(ICR) = TABULF(VPCL,KCL,9,1,ICR,1,ARGCL,YEAR)
TPCL = TPCL + PCL(ICR)
CRPLND(ICR) = PCL(ICR)*AGLNDC
CONTINUE
PCL(10) = 1. - TPCL
CRPLND(10) = PCL(10)*AGLNDC
RETURN
END
```

```
      SUBROUTINE PRODCN
      COMMON /LINK/    KNDPRT, NPRT, TPRT(6), RCFRTR, PMRFB(19,2),
     +                 VPMRF1(4), VPMRF2(4), VPMRF3(4), VPMRF4(4),
     +                 ARGMF1(4), ARGMF2(4), ARGMF3(4), ARGMF4(4),
     +                 POPL70(7), POPL85(7), FERTDC(3), CULLR(3),
     +                 VPCDLF(4), VPCDLN(4), VPCL(3,9), VYLD(3,17),
     +                 RINP70(17,12), RRINP(17,12), VPCDEM(3,17),
     +                 PRP(17), RTAX(17), PLNF
      COMMON /PRINTC/ IPRT,NPVAR, VAROUT(75,7), POPMI, TPOPF, TYGA,
     +                 VALAD, AGLND, AGLNDC, TYGAL, TPDEM, TPFT,
     +                 CBRT, CDRT, GFR, FERTR(19), TFERT, TPOPG1,
     +                 TPOPG2, TPOPG3, TPOPG4, PPOPG1, PPOPG2, PPOPG3,
     +                 DEPRAT, FPOPG1, FPOPG2, FPOPG3, FPOPG4, PFPG1,
     +                 PFPG2, PFPG3, FDPRAT, PCNI, AGLNPC, POPLS(7),
     +                 GYPU(17), COST(17), PFTPU(17), POPDC(3), AGLNDL,
     +                 CRPLND(10), AGPROD(17), COMAID(17), CONDEM(17),
     +                 SUPDEM(17), NETEXP, TPFTN, COSLAB, FARMY,
     +                 YPCAP, XLABS, TDEM(12)
      COMMON / MICH/    YEAR, T, DT, NENT, NCR, NL, NINP, TPOPNF, TPFL,
     +                 TPNFL, CULLDC, DEMNFL, TYC, ANLND(7), YC(17),
     +                 EXPIMP(17), YGA(17), PFT(17), VALADC(10),
     +                 VALADL(7), DEMINP(17,12), FRMLAB, POPF(19,2),
     +                 POPNF(19,2), PRINP(12)
      DIMENSION ARGYD(3), RINP(17,12), RINPDH(12), YLD(17)
      DATA PDCCS / .5 /
      DATA KYD / 3 /
      DATA ARGYD / 1964., 1980., 1985. /
      DATA RINPDH /    0.,    0.,    0.,    0., 400., 400.,    0., 150.,
     +                 6000.,  60.,  10.,    0.  /

C         AGRICULTURAL PRODUCTION
C
      DO 20 IENT=1,NENT
      YLD(IENT) = TABULF(VYLD,KYD,NENT,1,IENT,1,ARGYD,YEAR)
20    CONTINUE
      DO 30 IENT=1,NCR
      AGPROD(IENT) = YLD(IENT)*CRPLND(IENT)
30    CONTINUE
      AGPROD(11) = YLD(11)*(POPLS(1)+PDCCS*CULLDC)
      DO 40 IENT=12,NENT
      AGPROD(IENT) = YLD(IENT)*POPLS(IENT-NCR)
40    CONTINUE
C
C         AGRICULTURAL DEMAND FOR INPUTS
C
      RINPDH(10) = 50. + 2.*T
      DO 70 JIN=1,NINP
      DO 50 IENT=1,NENT
      RINP(IENT,JIN) = RINP70(IENT,JIN) + RRINP(IENT,JIN)
50    CONTINUE
      DO 55 IENT=1,NCR
      DEMINP(IENT,JIN) = RINP(IENT,JIN)*CRPLND(IENT)
55    CONTINUE
      DEMINP(11,JIN) = RINP(11,JIN)*POPLS(1)
      DEMINP(12,JIN) = RINP(12,JIN)*POPLS(2) + RINPDH(JIN)*POPDC(1)
      DO 60 IENT=13,NENT
      DEMINP(IENT,JIN) = RINP(IENT,JIN)*POPLS(IENT-10)
60    CONTINUE
70    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DEMAND
      COMMON /LINK/    KNOPRT, NPRT, TPRT(6), RCFRTR, PMRFB(19,2),
     +                 VPMRF1(4), VPMRF2(4), VPMRF3(4), VPMRF4(4),
     +                 ARGMF1(4), ARGMF2(4), ARGMF3(4), ARGMF4(4),
     +                 POPL70(7), POPL85(7), FERTDC(3), CULLR(3),
     +                 VPCDLF(4), VPCDLN(4), VPCL(3,9), VYLD(3,17),
     +                 RINP70(17,12), RRINP(17,12), VPCDEM(3,17),
     +                 PRP(17), RTAX(17), PLNF
      COMMON /PRINTC/ IPRT,NPVAR, VAROUT(75,7), POPMI, TPOPF, TYGA,
     +                 VALAD, AGLND, AGLNDC, TYGAL, TPDEM, TPFT,
     +                 CBRT, CDRT, GFR, FERTR(19), TFERT, TPOPG1,
     +                 TPOPG2, TPOPG3, TPOPG4, PPOPG1, PPOPG2, PPOPG3,
     +                 DEPRAT, FPOPG1, FPOPG2, FPOPG3, FPOPG4, PFPG1,
     +                 PFPG2, PFPG3, FDPRAT, PCNI, AGLNPC, POPLS(7),
     +                 GYPU(17), COST(17), PFTPU(17), POPDC(3), AGLNDL,
     +                 CRPLND(10), AGPROD(17), COMAID(17), CONDEM(17),
     +                 SUPDEM(17), NETEXP, TPFTN, COSLAB, FARMY,
     +                 YPCAP, XLABS, TDEM(12)
      COMMON / MICH/    YEAR, T, DT, NENT, NCR, NL, NINP, TPOPNF, TPFL,
     +                 TPNFL, CULLDC, DEMNFL, TYC, ANLND(7), YC(17),
     +                 EXPIMP(17), YGA(17), PFT(17), VALADC(10),
     +                 VALADL(7), DEMINP(17,12), FRMLAB, POPF(19,2),
     +                 POPNF(19,2), PRINP(12)
      DIMENSION ARGDEM(3), PCDEM(17), TDEMMI(17)
      DATA KDEM / 3 /
      DATA ARGDEM / 1970., 1980., 1985. /
C
C         DEMAND FOR AG PRODUCTION AS AG INPUTS
C
      DO 30 IENT=1,NENT
      COMAID(IENT) = 0.
      CONTINUE
      DO 40 IENT=1,NENT
      COMAID(1) = COMAID(1) + DEMINP(IENT,5)
      COMAID(2) = COMAID(2) + DEMINP(IENT,6)
      COMAID(7) = COMAID(7) + DEMINP(IENT,8)
      IF(IENT .LT. 11) GO TO 40
      COMAID(8) = COMAID(8) + DEMINP(IENT,9)
40    CONTINUE
      COMAID(6) = DEMINP(6,7)
C
C         DEMAND FOR AG PRODUCTION FOR HUMAN CONSUMPTION
C
      DO 50 IENT=1,NENT
      PCDEM(IENT) = TABULF(VPCDEM,KDEM,NENT,1,IENT,1,ARGDEM,YEAR)
      CONDEM(IENT) = PCDEM(IENT)*POPMI
C
C         TOTAL DEMAND
C
      TDEMMI(IENT) = COMAID(IENT) + CONDEM(IENT)
C
C         EXPORTS/IMPORTS
C
      EXPIMP(IENT) = AGPROD(IENT) - TDEMMI(IENT)
      CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ACCENT
      COMMON /LINK/    KNDPRT, NPRT, TPRT(6), RCFRTR, PMRFB(19,2),
     +                 VPMRF1(4), VPMRF2(4), VPMRF3(4), VPMRF4(4),
     +                 ARGMF1(4), ARGMF2(4), ARGMF3(4), ARGMF4(4),
     +                 POPL70(7), POPL85(7), FERTDC(3), CULLR(3),
     +                 VPCDLF(4), VPCDLN(4), VPCL(3,9), VYLD(3,17),
     +                 RINP70(17,12), RRINP(17,12), VPCDEM(3,17),
     +                 PRP(1,17), RTAX(1,17), PLNF
      COMMON /PRINTC/ IPRT, NPVAR, VAROUT(75,7), POPMI, TPOPF(1),
     +                TYGA(1), VALAD(1), AGLND, AGLNDC, TYGAL(1),
     +                TPDEM(1), TPFT(1),
     +                CBRT, CDPT, GFR, FERTR(19), TFERT, TPOPG1,
     +                TPOPG2, TPOPG3, TPOPG4, PPOPG1, PPOPG2, PPOPG3,
     +                DEPRAT, FPOPG1, FPOPG2, FPOPG3, FPOPG4, PFPG1,
     +                PFPG2, PFPG3, FDPRAT, PCNI(1), AGLNPC,
     +                POPLS(1,7), GYPU(1,17), COST(1,17), PFTPU(1,17),
     +                POPDC(3), AGLNDL, CRPLND(1,10), AGPROD(1,17),
     +                COMAID(1,17), CONDEM(1,17), SUPDEM(1,17),
     +                NETEXP(1), TPFTN(1), COSLAB(1),
     +                FARMY(1), YPCAP(1), XLABS(1), TDEM(1,12)
      COMMON / MIC4/   YEAR, T, DT, NENT, NCR, NL, NINP, TPOPNF, TPFL,
     +                TPNFL, CULLDC, DEMNFL, TYC(1), ANLND(7),
     +                YC(1,17), EXPIMP(1,17), YGA(1,17), PFT(1,17),
     +                VALADC(1,10), VALADL(1,7), DEMINP(1,17,12),
     +                FRMLAB(1), POPF(19,2), POPNF(19,2), PRINP(1,12)
      DIMENSION EXP(1,17,12), FCONR(1,17), PCCONF(1,17), PFTN(1,17)
      DIMENSION PTAX(1,17), RNUT(1,1,1), TNUT(1,1), TPTAX(1)
      DIMENSION TAGDEM(1)
      DATA NREG,NNUT,NCINP,NLINP / 1, 0, 4, 9 /
      DATA PCCONF / 17*0. /
      DATA PRINP / .0600, .1000, .0500, 1.000, .0241, .0167, .1220,
     +             .0467, .0110, 1.000, 3.000, 1.500 /
      DO 100 IR=1,NREG
      PRINP(IR,11) = PRINP(IR,11) + .04*DT
      PRINP(IR,12) = PRINP(IR,12) + .04*DT
      PRP(IR,17) = PRP(IR,17) + 2.*DT
      XLABS(IR) = FRMLAB(I
      VALAD(IR) = 0.
      NETEXP(IR) = 0.
      COSLAB(IR) = 0.
      TPFT(IR) = 0.
      TAGDEM(IR) = 0.
      TYGAL(IR) = 0.
      TPTAX(IR) = 0.
      TPFTN(IR) = 0.
      TYC(IR) = 0.
      TYGA(IR) = 0.
      DO 5 KIN=1,NINP
      TDEM(IR,KIN) = 0.
5     CONTINUE
      IF(NNUT .GT. 0) 10,25
10    DO 20 KN=1,NNUT
      TNUT(IR,KN) = 0.
20    CONTINUE
25    DO 95 JEN=1,NENT
      IF(JEN .NE. 10) 26,27
26    SUPDEM(IR,JEN) = AGPROD(IR,JEN)/(CONDEM(IR,JEN)+COMAID(IR,JEN))
      GO TO 28
27    SUPDEM(IR,JEN) = 0.
28    YGA(IR,JEN) = PRP(IR,JEN)*AGPROD(IR,JEN
      TYGA(IR) = TYGA(IR) + YGA(IR,JEN)
```

```
      TAGDEM(IR) = TAGDEM(IR) + (CONDEM(IR,JEN) + COMAID(IR,JEN))*
     +                PRP(IR,JEN)
      FCONR(IR,JEN) = PCCONF(IR,JEN)*TPOPF(IR)
      YC(IR,JEN) = PRP(IR,JEN)*(AGPROD(IR,JEN)-FCONR(IR,JEN))
      TYC(IR) = TYC(IR) + YC(IR,JEN)
      XLABS(IR) = XLABS(IR) - DEMINP(IR,JEN,11) - DEMINP(IR,JEN,12)
      PFT(IR,JEN) = YC(IR,JEN)
      DO 30 KIN = 1,NINP
      EXP(IR,JEN,KIN) = PRINP(IR,KIN)*DEMINP(IR,JEN,KIN)
      PFT(IR,JEN) = PFT(IR,JEN) - EXP(IR,JEN,KIN)
      TDEM(IR,KIN) = TDEM(IR,KIN) + DEMINP(IR,JEN,KIN)
30    CONTINUE
      TPFT(IR) = TPFT(IR) + PFT(IR,JEN)
C
C         VALUE ADDED
C
      IF(JEN .LE. NCR) 35,45
35    VALADC(IR,JEN) = YGA(IR,JEN)
      DO 40 KIN=1,NCINP
      VALADC(IR,JEN) = VALADC(IR,JEN) - EXP(IR,JEN,KIN)
40    CONTINUE
      VALAD(IR) = VALAD(IR) + VALADC(IR,JEN)
      GO TO 55
45    VALADL(IR,JEN-NCR) = YGA(IR,JEN)
      TYGAL(IR) = TYGAL(IR) + YGA(IR,JEN)
      DO 50 KIN=1,NLINP
      VALADL(IR,JEN-NCR) = VALADL(IR,JEN-NCR) - EXP(IR,JEN,KIN)
50    CONTINUE
      VALAD(IR) = VALAD(IR) + VALADL(IR,JEN-NCR)

C         TAXES
C
55    PTAX(IR,JEN) = RTAX(IR,JEN)*PFT(IR,JEN)
      IF(PTAX(IR,JEN) .LT. 0.) PTAX(IR,JEN) = 0.
      TPTAX(IR) = TPTAX(IR) + PTAX(IR,JEN)
C
C         NET PROFITS
      PFTN(IR,JEN) = PFT(IR,JEN) - PTAX(IR,JEN)
      TPFTN(IR) = TPFTN(IR) + PFTN(IR,JEN)
      PCNI(IR) = TPFTN(IR)/TPOPF(IR)
C
      COSLAB(IR) = COSLAB(IR) + EXP(IR,JEN,11) + EXP(IR,JEN,12)
      NETEXP(IR) = NETEXP(IR) + EXPIMP(IR,JEN)*PRP(IR,JEN)
C
C         PER UNIT RETURNS AND PROFITS
C
      IF(JEN .LE. NCR)70,75
70    GYPU(IR,JEN) = YGA(IR,JEN)/CRPLND(IR,JEN)
      PFTPU(IR,JEN) = PFTN(IR,JEN)/CRPLND(IR,JEN)
      GO TO 80
75    GYPU(IR,JEN) = YGA(IR,JEN)/POPLS(IR,JEN-NCR)
      PFTPU(IR,JEN) = PFTN(IR,JEN)/POPLS(IR,JEN-NCR)
      COST(IR,JEN) = GYPU(IR,JEN) - PFTPU(IR,JEN)
80    IF(NNUT .GT. 0) 85,95
85    DO 90 KN=1,NNUT
      TNUT(IR,KN) = TNUT(IR,KN) + RNUT(IR,KN,JEN)*AGPROD(IR,JEN)
90    CONTINUE
95    CONTINUE
      FARMY(IR) = TPFTN(IR) + COSLAB(IR)
      YPCAP(IR) = FARMY(IR)/TPOPF(IR)
      TPDEM(IR) = TYGA(IR)/TAGDEM(IR)
```

```
100   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRINTS
      COMMON /LINK/    KNOPRT, NPRT, TPRT(6), RCFRTR, PMRF3(19,2),
     +                 VPMRF1(4), VPMRF2(4), VPMRF3(4), VPMRF4(4),
     +                 ARGMF1(4), ARGMF2(4), ARGMF3(4), ARGMF4(4),
     +                 POPL70(7), POPL85(7), FERTDC(3), CULLR(3),
     +                 VPCDLF(4), VPCDLN(4), VPCL(3,9), VYLD(3,17),
     +                 RINP70(17,12), RRINP(17,12), VPCDEM(3,17),
     +                 PRP(17), RTAX(17), PLNF
      COMMON /PRINTS/  IPRT,NPVAR,VAROUT(75,7), POPMI, TPOPF,TYGA,
     +                 VALAD, AGLND, AGLNDC, TYGAL, TPDEM, TPFT,
     +                 CBRT, CORT, GFR, FERTR(19), TFERT, TPOPG1,
     +                 TPOPG2, TPOPG3, TPOPG4, PPOPG1, PPOPG2, PPOPG3,
     +                 DEPRAT, FPOPG1, FPOPG2, FPOPG3, FPOPG4, PFPG1,
     +                 PFPG2, PFPG3, FDPRAT, PCNI, AGLNPC, POPLS(7),
     +                 GYPU(17), COST(17), PFTPU(17), POPDC(3), AGLNDL,
     +                 CRPLND(10), AGPROD(17), COMAID(17), CONDEM(17),
     +                 SUPDEM(17), NETEXP, TPFTN, COSLAB, FARMY,
     +                 YPCAP, XLABS, TDEM(12)
      COMMON / MICH/    YEAR, T, DT, NENT, NCR, NL, NINP, TPOPNF, TPFL,
     +                 TPNFL, CULLDC, DEMNFL, TYC, ANLND(7), YC(17),
     +                 EXPIMP(17), YGA(17), PFT(17), VALADC(10),
     +                 VALADL(7), DEMINP(17,12), FRMLAB, POPF(19,2),
     +                 POPNF(19,2), PRINP(12)
      DIMENSION VARNAM(75,5), NVAR(5)
      DATA (VARNAM(I,1),I=1,30) /          10HCBR       , 10HCDR       ,
     +      10HGEN FERT R, 10HFERT 10-14, 10HFERT 15-19, 10HFERT 20-24,
     +      10HFERT 25-29, 10HFERT 30-34, 10HFERT 35-39, 10HFERT 40-44,
     +      10HFERT 45-49, 10HTOTAL FERT, 10HPOP   0-14, 10HPOP  15-44,
     +      10HPOP  45-64, 10HPOP  64+  , 10HPCNT  0-14, 10HPCNT 15-64,
     +      10HPCNT 64+  , 10HDEP RATIO , 10HFPOP  0-14, 10HFPOP 15-44,
     +      10HFPOP 45-64, 10HFPOP 64+  , 10HPCNT  0-14, 10HPCNT 15-64,
     +      10HPCNT 64+  ,10HFDEP RATIO, 10HPER CAP PR, 10HPER CAP LD /
      DATA (VARNAM(I,2),I=1,29) /          10HPOP BEEF  , 10HG Y BEEF  ,
     +      10HCOS BEEF  , 10HN Y BEEF  , 10HPOP DAIRYH, 10HPOP DAIRYC,
     +      10HG Y DAIRY , 10HCOS DAIRY , 10HN Y DAIRY , 10HPOP HOGS  ,
     +      10HG Y HOGS  , 10HCOS HOGS  , 10HN Y HOGS  , 10HPOP SHEEP ,
     +      10HG Y SHEEP , 10HCOS SHEEP , 10HN Y SHEEP , 10HPOP POUL M,
     +      10HG Y POUL M, 10HCOS POUL M, 10HN Y POUL M, 10HPOP EGGS  ,
     +      10HG Y EGGS  , 10HCOS EGGS  , 10HN Y EGGS  , 10HPOP HORSES,
     +      10HG Y HORSES, 10HCOS HORSES, 10HN Y HORSES /
      DATA (VARNAM(I,3),I=1,31) /          10HLND LVST  , 10HLND CORN  ,
     +      10HLND SM GR , 10HLND FRUITS, 10HLND VEG   , 10HLND POTOES,
     +      10HLND D BEAN, 10HLND S BEAN, 10HLND HAY   , 10HLND SUGBEE,
     +      10HLND OTHER , 10HG Y CORN  , 10HG Y SM GR , 10HG Y FRUITS,
     +      10HG Y VEG   , 10HG Y POTOES, 10HG Y D BEAN, 10HG Y S BEAN,
     +      10HG Y HAY   , 10HG Y SUGBEE, 10HG Y OTHER , 10HN Y CORN  ,
     +      10HN Y SM GR , 10HN Y FRUITS, 10HN Y VEG   , 10HN Y POTOES,
     +      10HN Y D BEAN, 10HN Y S BEAN, 10HN Y HAY   , 10HN Y SUGBEE,
     +      10HN Y OTHER  /
      DATA (VARNAM(I,4),I=1,54) /          10HPRO CORN  , 10HAGD CORN  ,
     +      10HCON CORN  , 10HS/D CORN  , 10HPRO SM GR , 10HAGD SM GR ,
     +      10HCON SM GR , 10HS/D SM GR , 10HPRO FRUITS, 10HCON FRUITS,
     +      10HS/D FRUITS, 10HPRO VEG   , 10HCON VEG   , 10HS/D VEG   ,
     +      10HPRO POTOES, 10HCON POTOES, 10HS/D POTOES, 10HPRO D BEAN,
     +      10HAGD D BEAN, 10HCON D BEAN, 10HS/D D BEAN, 10HPRO S BEAN,
     +      10HAGD S BEAN, 10HCON S BEAN, 10HS/D S BEAN, 10HPRO HAY   ,
     +      10HAGD HAY   , 10HCON HAY   , 10HS/D HAY   , 10HPRO SUGBEE,
     +      10HCON SUGBEE, 10HS/D SUGBEE, 10HPRO BEEF  , 10HCON BEEF  ,
     +      10HS/D BEEF  , 10HPRO DAIRY , 10HCON DAIRY , 10HS/D DAIRY ,
     +      10HPRO HOGS  , 10HCON HOGS  , 10HS/D HOGS  , 10HPRO SHEEP ,
     +      10HCON SHEEP , 10HS/D SHEEP , 10HPRO POUL M, 10HCON POUL M,
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     +      10HS/D POUL M, 10HPRO EGGS   , 10HCON EGGS   , 10HS/D EGGS   ,
     +      10HPRO HORSES, 10HCON HORSES, 10HS/D HORSES, 10HNETVAL EXP/
      DATA (VARNAM(I,5),I=1,10) /                          10HNET PROFIT,
     +      10HLABOR COST, 10HFARM Y     , 10HY PERCAP   , 10HEXTR LABOR,
     +      10HDEM NITRO , 10HDEM PHOS   , 10HDEM POTAS , 10HDEM HERB   ,
     +      10HDEM CAP/YR /
      DATA (VAROUT(I,1),I=1,9) /           10HTOT POP    , 10HFARM POP   ,
     +      10HAG LAND   , 10HCROP LAND , 10H$ LIVESTOC, 10HGROSS Y    ,
     +      10HVALUE ADD , 10H$ RETURNS , 10HPROD/DEM    /
      DATA NVAR / 30, 29, 31, 54, 10 /
      IPRT = IPRT + 1
      IF(IPRT .GT. 1) GO TO 30
C
C         SELECT LABELS FOR OUTPUT
C
      NPVAR = 9
      IF(KNDPRT .EQ. 0) RETURN
      NPVAR = NVAR(KNDPRT) + NPVAR
      DO 20 IVAR=10,NPVAR
      VAROUT(IVAR,1) = VARNAM(IVAR-9,KNDPRT)
20    CONTINUE
      RETURN
C
C         BASIC OUTPUT
C
30    VAROUT(1,IPRT) = POPMI
      VAROUT(2,IPRT) = TPOPF
      VAROUT(3,IPRT) = AGLND
      VAROUT(4,IPRT) = AGLNDC
      VAROUT(5,IPRT) = TYGAL
      VAROUT(6,IPRT) = TYGA
      VAROUT(7,IPRT) = VALAD
      VAROUT(8,IPRT) = TPFT
      VAROUT(9,IPRT) = TPDEM
      DO 32 I=1,8
      IDUM = VAROUT(I,IPRT) + .5
      VAROUT(I,IPRT) = IDUM
32    CONTINUE
      IF(KNDPRT .LT. 1) RETURN
      GO TO (35, 60, 100, 200, 300), KNDPRT
C
C         HUMAN POPULATION OUTPUT VARIABLES
C
35    VAROUT(10,IPRT) = CBRT
      VAROUT(11,IPRT) = CDRT
      VAROUT(12,IPRT) = GFR
      DO 40 IC=4,11
      VAROUT(IC+9,IPRT) = FERTR(IC)*1000
40    CONTINUE
      VAROUT(21,IPRT) = TFERT
      VAROUT(22,IPRT) = TPOPG1
      VAROUT(23,IPRT) = TPOPG2
      VAROUT(24,IPRT) = TPOPG3
      VAROUT(25,IPRT) = TPOPG4
      VAROUT(26,IPRT) = PPOPG1
      VAROUT(27,IPRT) = PPOPG2
      VAROUT(28,IPRT) = PPOPG3
      VAROUT(29,IPRT) = DEPRAT
      VAROUT(30,IPRT) = FPOPG1
      VAROUT(31,IPRT) = FPOPG2
      VAROUT(32,IPRT) = FPOPG3
```

```
      VAROUT(33,IPRT) = FPOPG4
      VAROUT(34,IPRT) = PFPG1
      VAROUT(35,IPRT) = PFPG2
      VAROUT(36,IPRT) = PFPG3
      VAROUT(37,IPRT) = FOPRAT
      VAROUT(38,IPRT) = PCNT
      VAROUT(39,IPRT) = AGLNPC
      DO 50 I=10,NPVAR
      IF(VAROUT(I,IPRT) .LT. 200.) GO TO 50
      IDUM = VAROUT(I,IPRT) + .5
      VAROUT(I,IPRT) = IDUM
50    CONTINUE
C
C         LIVESTOCK POPULATION OUTPUT VARIABLES
C
60    IDUM = POPLS(1) + .5
      VAROUT(10,IPRT) = IDUM
      VAROUT(11,IPRT) = GYPU(11)
      VAROUT(12,IPRT) = COST(11)
      VAROUT(13,IPRT) = PFTPU(11)
      IDUM = POPDC(1) + .5
      VAROUT(14,IPRT) = IDUM
      IVAR = 15
      DO 70 IEN=12,17
      IDUM = POPLS(IEN-NCR) + .5
      VAROUT(IVAR,IPRT) = IDUM
      VAROUT(IVAR+1,IPRT) = GYPU(IEN)
      VAROUT(IVAR+2,IPRT) = COST(IEN)
      VAROUT(IVAR+3,IPRT) = PFTPU(IEN)
      IVAR = IVAR + 4
      CONTINUE
      RETURN
C
C         LAND ALLOCATION OUTPUT VARIABLE
C
100   VAROUT(10,IPRT) = AGLNDL
      DO 110 ICR=1,10
      VAROUT(10+ICR,IPRT) = CRPLND(ICR)
110   CONTINUE
      DO 120 ICR=1,10
      VAROUT(20+ICR,IPRT) = GYPU(ICR)
120   CONTINUE
      DO 130 ICR=1,10
      VAROUT(30+ICR,IPRT) = PFTPU(ICR)
130   CONTINUE
      GO TO 350
C
C         AG PRODUCTION AND DEMAND OUTPUT VARIABLES
C
200   IVAR = 9
      IEN1 = 1
      IEN2 = 9
205   DO 230 IENT=IEN1,IEN2
      IVAR = IVAR + 1
      IDUM = AGPROD(IENT) + .5
      VAROUT(IVAR,IPRT) = IDUM
      IVAR = IVAR + 1
      IF(COMAID(IENT) .GT. 0.) 210,220
210   IDUM = COMAID(IENT) + .5
      VAROUT(IVAR,IPRT) = IDUM
      IVAR = IVAR + 1
```

```
220   IDUM = CONDEM(IENT) + .5
      VAROUT(IVAR,IPRT) = IDUM
      IVAR = IVAR + 1
      VAROUT(IVAR,IPRT) = SUPDEM(IENT)
      CONTINUE
      IF(IEN1 .GT. 1) GO TO 240
      IEN1 = 11
      IEN2 = 17
      GO TO 205
240   VAROUT(IVAR+1,IPRT) = NET
      RETURN
C
C         ACCOUNTING
C
300   VAROUT(10,IPRT) = TPFTN
      VAROUT(11,IPRT) = COSLAB
      VAROUT(12,IPRT) = FARMY
      VAROUT(13,IPRT) = YPCAP
      VAROUT(14,IPRT) = XLABS
      VAROUT(15,IPRT) = TDEM(1)
      VAROUT(16,IPRT) = TDEM(2)
      VAROUT(17,IPRT) = TDEM(3)
      VAROUT(18,IPRT) = TDEM(4)
      VAROUT(19,IPRT) = TDEM(10)
350   DO 360 I=10,NPVAR
      IDUM = VAROUT(I,IPRT) + .5
      VAROUT(I,IPRT) = IDUM
360   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DEMOGC(POP, ROUT, ROUTAV,RP,DEL,DELP,KC,POPS,
                        TPOP, SR, DR, CDR, DTH, TDTH, NOBTH, PBF, BR,
                        CBR, BTH, TBTH, TMR, PMR, PLR, PGRN, PGRT, NK,
                        NC, NSEX, DT, T, ICALL)
      DIMENSION BR(NC), BTH(NSEX), DEL(NC,NSEX), DELP(NC,NSEX)
      DIMENSION DR(NC,NSEX), DTH(NC,NSEX), KC(NC,NSEX), PLR(NC,NSEX)
      DIMENSION PMR(NC,NSEX), POP(NC,NSEX), POPS(NC,NSEX)
      DIMENSION ROUT(NC,NSEX), ROUTAV(NC,NSEX), RP(NK,NC,NSEX)
      IF(ICALL .GT. 1) GO TO 52
      TPOP = 0.
      DO 50 K=1,NSEX
      IF(T .NE. 0.) GO TO 20
      DO 15 J=1,NC
      DELP(J,K) = DEL(J,K)
      IKC = KC(J,K)
      DO 10 I=1,IKC
      RP(I,J,K) = POP(J,K)/DEL(J,K)
10    CONTINUE
      ROUT(J,K) = RP(1,J,K)
15    CONTINUE
      GO TO 30
20    CALL DELLVF(BTH(K), ROUT(1,K), ROUTAV(1,K), RP(1,1,K), POP(1,K),
     +            PLR(1,K), DEL(1,K), DELP(1,K), DT, KC(1,K))
      DO 29 J=2,NC
      IF(KC(J,K) .LT. 1) GO TO 29
      CALL DELLVF(ROUTAV(J-1,K), ROUT(J,K), ROUTAV(J,K), RP(J,K),
     +            POP(J,K), PLR(J,K), DEL(J,K), DELP(J,K), DT, KC(J,K))
29    CONTINUE
30    POPS(K) = 0.
      DO 40 J=1,NC
      POPS(K) = POPS(K) + POP(J,K)
40    CONTINUE
      TPOP = TPOP + POPS(K)
50    CONTINUE
      IF(ICALL .EQ. 1) RETURN
52    TMR = 0.
      TDTH = 0.
      DO 54 K=1,NSEX
      DO 53 J=1,NC
      PLR(J,K) = PMR(J,K) + DR(J,K)
      DTH(J,K) = DR(J,K)*POP(J,K)
      IF(J .EQ. NC) DTH(J,K) = DTH(J,K) + ROUT(J,K)
      TDTH = TDTH + DTH(J,K)
      TMR = TMR + PMR(J,K)*POP(J,K)
53    CONTINUE
54    CONTINUE
      IF(NOBTH .EQ. 1) GO TO 65
      TBTH = 0.
      DO 55 J=1,NC
      TBTH = TBTH + BR(J)*POP(J,1)
55    CONTINUE
65    IF(NSEX .NE. 2) GO TO 68
      BTH(1) = PBF*TBTH
      BTH(2) = TBTH - BTH(1)
      IF(POPS(1) .EQ. 0.) GO TO 70
      SR = POPS(2)/POPS(1)
      GO TO 75
68    BTH(1) = TBTH
70    SR = 0.
75    IF(TPOP .EQ. 0.) GO TO 80
      CBR = TBTH/TPOP
```

```
CDR = TDTH/TPOP
PGRN = 100.*(CBR - CDR)
PGRT = PGRN - 100.*TMR/TPOP
RETURN
CBR = 0.
CDR = 0.
PGRN = 0.
PGRT = 0.
RETURN
END
```

```
SUBROUTINE DELLVF(RIN,ROUT,ROUTAV,R,STRG,PLR,DEL,DELP,DT,K)
DIMENSION R(1)
FK = FLOAT(K)
B = 1. + (DEL-DELP)/(FK*DT) + PLR*DELP/FK
IDT = 1. + 2.*DT*FK/DELP*AMAX1(B, 0.)
A = FK*DT/(DELP*FLOAT(IDT))
DELP = DEL
KM1 = K-1
ROUTAV = ROUT
DO 20 J=1,IDT
DO 10 I=1,KM1
R(I) = R(I) + A*(R(I+1)-B*R(I))
CONTINUE
R(K) = R(K) + A*(RIN-B*R(K))
ROUTAV = ROUTAV + R(1)
CONTINUE
STRG = 0.
DO 30 I=1,K
STRG = STRG + R(I)*DEL/FK
CONTINUE
ROUT = R(1)
ROUTAV = (ROUTAV-ROUT)/FLOAT(IDT
RETURN
END
```

```
      SUBROUTINE DEMOGD(POP, POPS, TPOP, SR, CLEN, AR, DR, CDR,
     +                  DTH, TDTH, NOBTH, PBF, BR, CBR, BTH, TBTH,
     +                  PLR, PMR, TMR, PGRN, PGRT, NC, NSEX, DT, T,
     +                  ICALL)
      DIMENSION AR(NC,NSEX), BR(NC), BTH(NSEX)
      DIMENSION CLEN(NC,NSEX), DR(NC,NSEX), DTH(NC,NSEX), PLR(NC,NSEX)
      DIMENSION PMR(NC,NSEX), POP(NC,NSEX), POPS(NSEX)
      IF(ICALL .GT. 1) GO TO 52
      TPOP = 0.
      DO 50 K=1,NSEX
      POPS(K) = 0.
      DO 40 J=1,NC
      IF(T .EQ. 0.) GO TO 20
      IF(J .NE. 1) GO TO 15
      POP(1,K) = POP(1,K)*(1.-DT*PLR(1,K)) + DT*(BTH(K)-AR(1,K))
      GO TO 18
15    POP(J,K) = POP(J,K)*(1.-DT*PLR(J,K)) + DT*(AR(J-1,K)-AR(J,K))
18    IF(AMOD(T, CLEN(J,K)) .EQ. 0.) GO TO 20
      AR(J,K) = AR(J,K)*(1.-DT*PLR(J,K))
      GO TO 25
20    AR(J,K) = POP(J,K)/CLEN(J,K)
25    IF(POP(J,K) .GT. 0.) GO TO 30
      POP(J,K) = 0.
      AR(J,K) = 0.
30    POPS(K) = POPS(K) + POP(J,K)
40    CONTINUE
      TPOP = TPOP + POPS(K)
50    CONTINUE
      IF(ICALL .EQ. 1) RETURN
      TMR = 0.
      TDTH = 0.
      DO 54 K=1,NSEX
      DO 53 J=1,NC
      DTH(J,K) = DR(J,K)*POP(J,K)
      IF(J .EQ. NC) DTH(J,K) = DTH(J,K) + AR(J,K)
      TDTH = TDTH + DTH(J,K)
      PLR(J,K) = PMR(J,K) + DR(J,K)
      TMR = TMR + PMR(J,K)*POP(J,K)
53    CONTINUE
54    CONTINUE
      IF(NOBTH .EQ. 1) GO TO 65
      TBTH = 0.
      DO 55 J=1,NC
      TBTH = TBTH + BR(J)*POP(J,1)
55    CONTINUE
65    IF(NSEX .NE. 2) GO TO 68
      BTH(1) = PBF*TBTH
      BTH(2) = TBTH - BTH(1)
      IF(POPS(1) .EQ. 0.) GO TO
      SR = POPS(2)/POPS(1)
      GO TO 75
68    BTH(1) = TBTH
70    SR = 0.
75    IF(TPOP .EQ. 0.) GO TO 80
      CBR = TBTH/TPOP
      CDR = TDTH/TPOP
      PGRN = 100.*(CBR - CDR)
      PGRT = PGRN - 100.*TMR/TPOP
      RETURN
80    CBR = 0.
      CDR = 0.
```

```
      PGRN = 0.
      PGRT = 0.
      RETURN
      END
```

```
      FUNCTION TABELS(VAL,K,SMALL,DIFF,XARG)
      DIMENSION VAL(K)
      DUM = XARG - SMALL
      IF(DUM .LT. 0.) DUM = 0.
      IF(DUM .GT. FLOAT(K-1)*DIFF) DUM = FLOAT(K-1)*DIFF
      I = 1. + DUM/DIFF
      IF(I .EQ. K) I = K-1
      TABELS = VAL(I) + ((VAL(I+1) - VAL(I))/DIFF)*(DUM - FLOAT(I-1)*
     +         DIFF)
      RETURN
      END



      FUNCTION TABULS(VAL,K,ARG,XARG)
      DIMENSION VAL(K),ARG(K)
      DUM = XARG
      IF(DUM .GT. ARG(K)) DUM = ARG(K)
      IF(DUM .LT. ARG(1)) DUM = ARG(1)
      DO 10 I=2,K
      IF (DUM .GT. ARG(I))GO TO 10
      TABULS = VAL(I-1) + ((VAL(I) - VAL(I-1))/(ARG(I) - ARG(I-1)))*
     +         (DUM - ARG(I-1))
      RETURN
10    CONTINUE
      END



      FUNCTION TABULF(VAL,K,L,M,IL,IM,ARG,XARG)
      DIMENSION VAL(K,L,M),ARG(K)
      DUM = XARG
      IF(DUM .GT. ARG(K)) DUM = ARG(K)
      IF(DUM .LT. ARG(1)) DUM = ARG(1)
      DO 10 I=2,K
      IF(DUM .GT. ARG(I)) GO TO 10
      TABULF = VAL(I-1,IL,IM) + ((VAL(I,IL,IM) - VAL(I-1,IL,IM))/
     +         (ARG(I) - ARG(I-1)))*(DUM - ARG(I-1))
      RETURN
10    CONTINUE
      END



      SUBROUTINE DEL(RIN,ROUT,R,DELAY,DT,K)
      DIMENSION R(1)
      KM1 = K-1
      A = FLOAT(K)*DT/DELAY
      IF(K .EQ. 1) GO TO 20
      DO 10 I=1,KM1
      R(I) = R(I) + A*(R(I+1)-R(I))
10    CONTINUE
      R(K) = R(K) + A*(RIN-R(K))
      ROUT = R(1)
      RETURN
      END
```