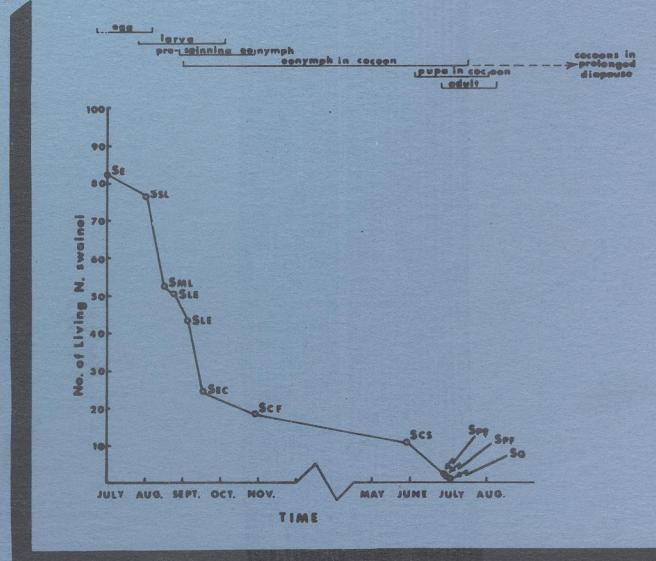
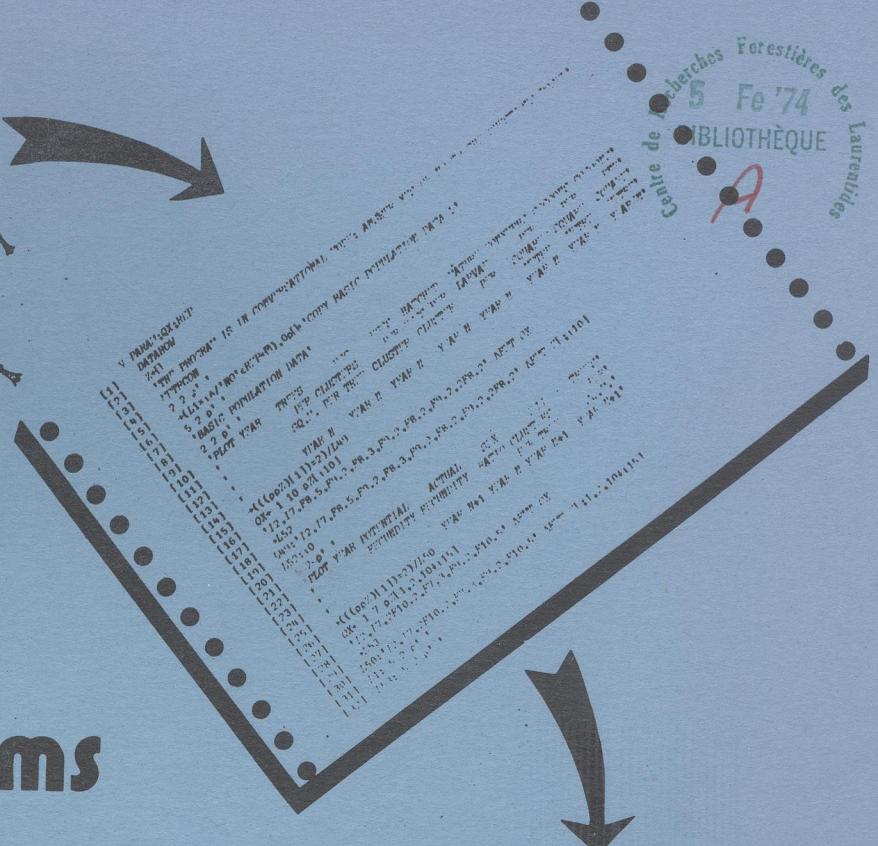


**APL/360
PROGRAMS
for the
development
and analysis
of life tables
for the
SWAINE JACK
PINE SAWFLY**



J. M. McLEOD
and R. LAGUË

CENTRE DE RECHERCHES FORESTIERES
DES LAURENTIDES
SERVICE CANADIEN DES FORETS

APL/360 PROGRAMS FOR THE DEVELOPMENT
AND ANALYSIS OF LIFE TABLES FOR THE
SWAINE JACK PINE SAWFLY

J.M. McLEOD and R. LAGUE

RAPPORT D'INFORMATION LAU-X-4

OCTOBER 1973

CENTRE DE RECHERCHES FORESTIERES DES LAURENTIDES
MINISTÈRE DE L'ENVIRONNEMENT
SERVICE CANADIEN DES FORÊTS
1080 ROUTE DU VALLON
C.P. 3800
STE-FOY, QUÉBEC
G1V 4C7

Copies available

Cover: Gilles Désalliers

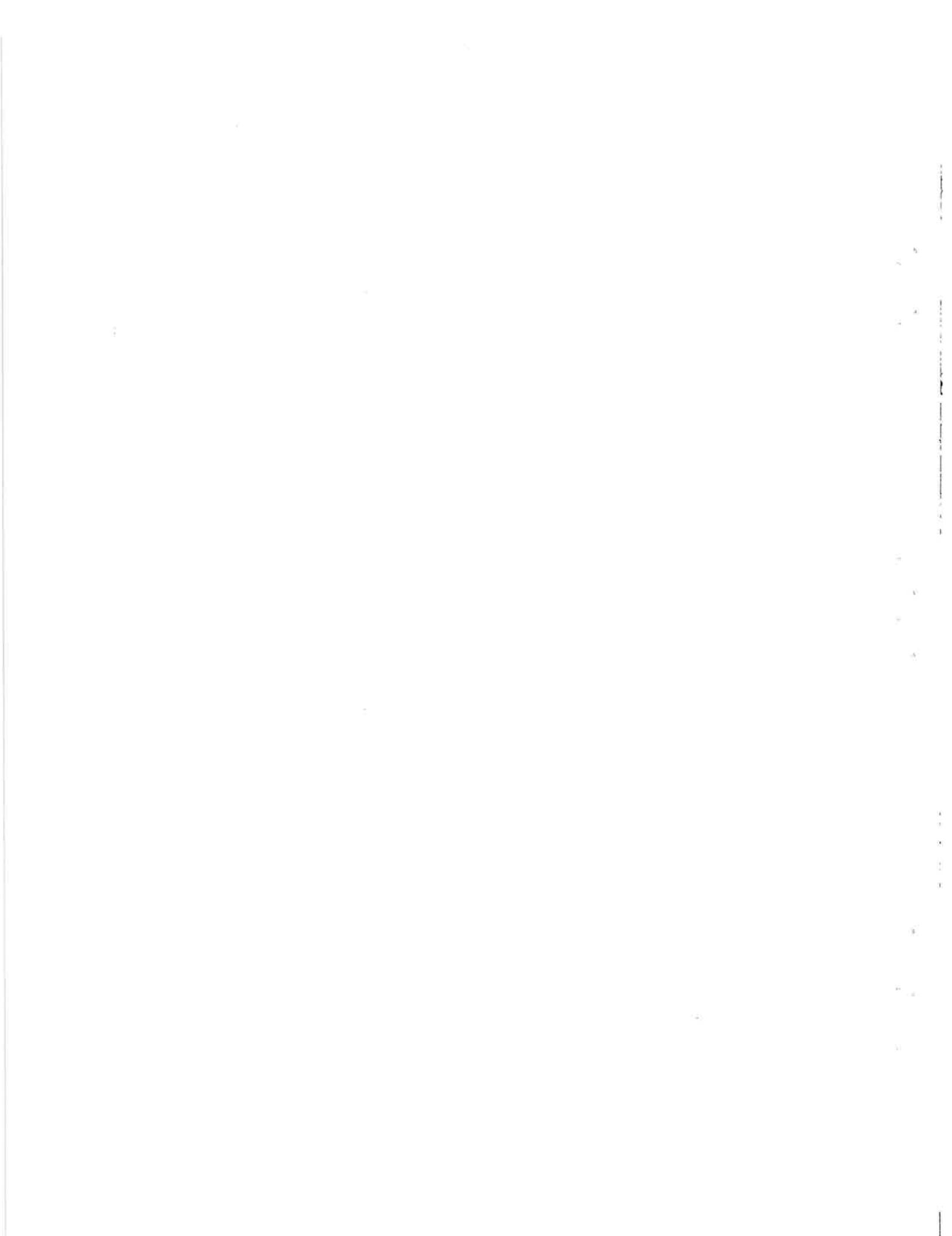
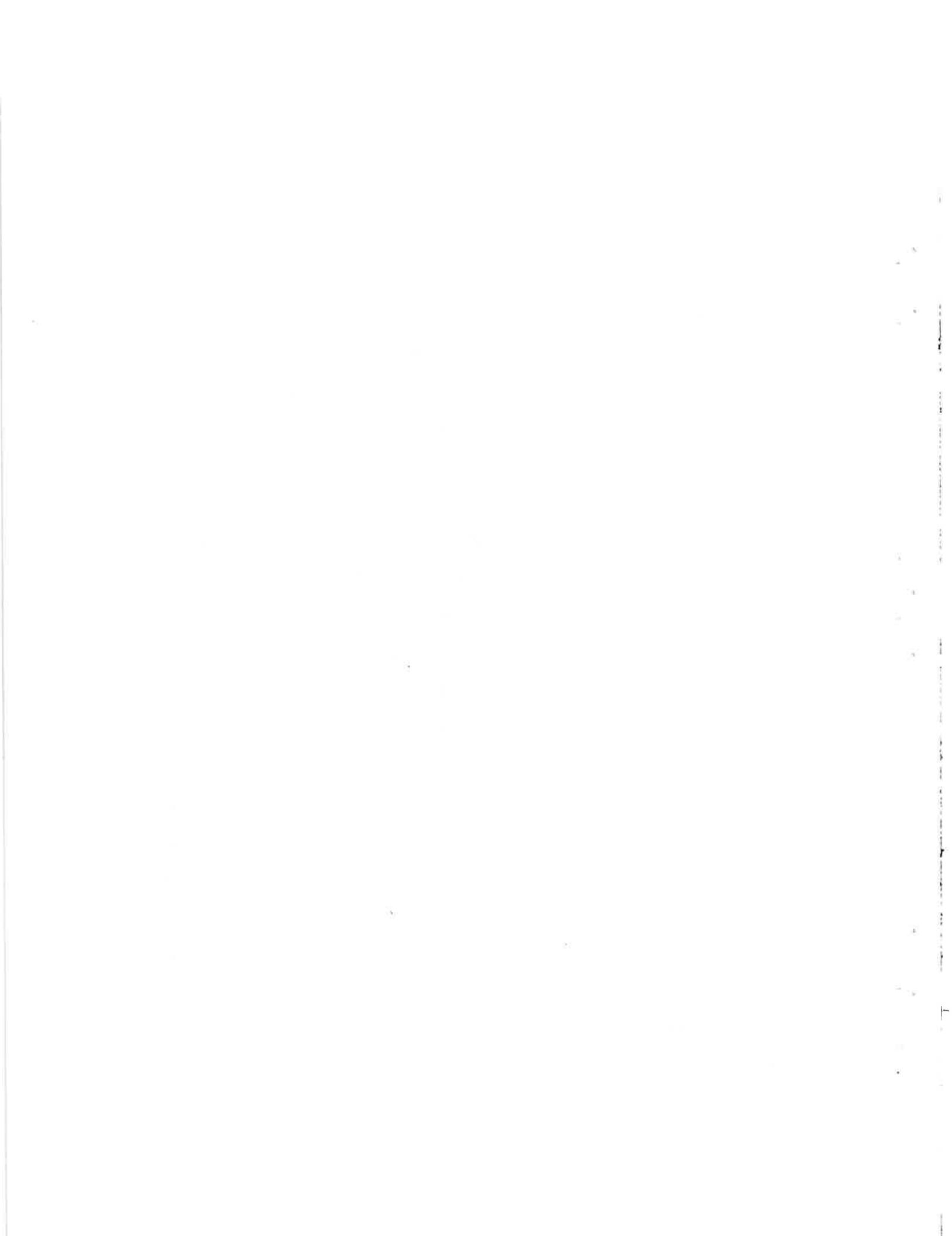


TABLE OF CONTENTS

	PAGE
1. INTRODUCTION	1
2. DESCRIPTIONS OF PROGRAMS	5
1. <i>Main Program</i> VARLEYMIX - - - - -	5
2. <i>Sub Program</i> PARAM - - - - -	8
3. <i>Sub Program</i> LIVING - - - - -	12
4. <i>Sub Program</i> TABLE - - - - -	15
5. <i>Sub Program</i> SURV - - - - -	19
6. <i>Sub Program</i> VARLEYLOG - - - - -	23
7. <i>Sub Program</i> VARLEY - - - - -	26
8. <i>Sub Program</i> EGGTREND - - - - -	29
9. <i>Sub-Sub Program</i> DATAHOW - - - - -	32
10. <i>Sub-Sub Program</i> METRCON - - - - -	35
11. <i>Sub-Sub Program</i> TWIST - - - - -	38
12. <i>Sub-Sub Program</i> LIVCAL - - - - -	41
13. <i>Sub-Sub Program</i> TABFORM - - - - -	44
14. <i>Sub-Sub Program</i> TABMAT - - - - -	47
15. <i>Sub-Sub Program</i> TABVEC - - - - -	50
16. <i>Sub-Sub Program</i> TRANS - - - - -	53
17. <i>Sub-Sub Program</i> LOGCAL - - - - -	56
18. <i>Sub-Sub Program</i> KCAL - - - - -	59
3. A SPECIMEN PROGRAM	62
4. REFERENCES	73



ABSTRACT

APL/360 programs for the development and analyses of life tables for the Swaine jack pine sawfly, *Neodiprion swainei* Middleton, are described. Written in conversational mode, the programs provide options for printout of basic data summaries, number of living insects per square metre by age intervals, age-specific life tables, loge survival rates and Varley and Gradwell "k" factor analyses. The data are stored as global variables in the APL system if further operations are desired.

RESUME

Nous décrivons ici une série de programmes APL/360 pour le développement et l'analyse des tables de survie de la tenthredine de Swaine, *Neodiprion swainei* Middleton. Ecrits en mode conversationnel, ces programmes fournissent des options pour l'impression des données de base, le nombre d'insectes vivants par mètre carré en rapport avec les divers âges de l'insecte, les tables de survie relatives à l'âge de l'insecte, les logarithmes naturels des taux de survivance, ainsi que les analyses "k" de Varley et Gradwell. Les données sont mises en mémoire comme variables globales dans le système APL si d'autres des opérations ultérieures sont désirées.

INTRODUCTION

The APL/360 programs (Gilman and Rose, 1970) described herein were developed for the construction and analysis of life tables for the Swaine jack pine sawfly, *Neodiprion swainei* Middleton as part of an information retrieval system for this insect. They consist of a main program, VARLEYMIX, within which are a number of sub-programs performing the operations described below. The results of a number of the programs are stored as global variables in the APL system. Details for the construction and analysis of life tables upon which these programs are based, are found in Southwood (1966).

<u>Sub-Program</u>	<u>Operations</u>	<u>Stored as Global</u>	<u>Global</u>
<u>Name</u>	<u>Performed</u>	<u>Variable in APL</u>	<u>Variable</u>
		<u>System?</u>	<u>Name</u>
<i>PARAM</i>	Prints basic population data from which the life tables are const- ructed, with headings	No	
<i>LIVING</i>	Prints the number of living insects per sq. metre for 9 sawfly age intervals, with headings	Yes	<i>MOOSE</i>
<i>TABLE</i>	Prints age-specific life tables for 9 sawfly age intervals, with headings	No	

<u>Sub-Program</u>	<u>Operations</u>	<u>Stored as Global</u>	<u>Global</u>
<u>Name</u>	<u>Performed</u>	<u>Variable in APL</u>	<u>Variable</u>
		<u>System?</u>	<u>Name</u>
<i>SURV</i>	Prints logarithmic transformations of the survival rates for 9 sawfly age intervals, with headings	Yes	<i>LOGSUR</i>
<i>VARLEYLOG</i>	Prints logarithmic transformations of the number of living insects per sq. metre, with headings	Yes	<i>SPOCK</i>
<i>VARLEY</i>	Prints Varley and Gradwell k-factors, with headings	Yes	<i>GRADWELL</i>
<i>EGGTREND</i>	Prints logarithmic transformations of the number of living insects per sq. metre in year N vs. the number in year N + 1, with headings	Yes	<i>POP</i>

The programs are written in conversational mode. By entering YES or NO in answer to the questions posed, the operator has the following options:

- (a) Using the main program VARLEYMIX, or any-one of the sub programs listed above
- (b) Obtaining a printout of the results
- (c) Obtaining an exit from the main program

The basic population data on which the life tables and analyses are based are stored as global variables in the APL system under the names listed below. Further details on the location of the study areas are found in McLeod (1973).

<u>Variable</u>	<u>Study Area</u>	<u>No. of Years of</u>
<u>Name</u>	<u>Number</u>	<u>Information</u>
BAUDE	7	3 (1970-1972)
CAOUS	5	17 (1956-1972)
CHEV	6	7 (1966-1972)
IROQ	3	4 (1962-1965)
MCL	1	9 (1964-1972)
ORISK	2	9 (1964-1972)
RIVMAR	4	11 (1962-1972)

If any one of the above variable names is entered, no knowledge of APL operations is required for the operation of the programs, since they are in conversational mode. However, if entry of other combinations of years and study areas is desired, the reader is referred to Gilman and Rose (op. cit.) for elementary matrix operations with the APL functions take, (\uparrow), drop (\downarrow), index ([]), catenate (,), index generator ($_$), and semicolon (;) as used in indexing.

The number of plot years of basic information which may be used in a single program pass varies according to the program used, as outlined below:

<u>Program</u>	<u>No. of Plot-Years of Information</u>
<u>Name</u>	<u>Handled in Single Program Pass</u>
<i>VARLEYMIX</i>	20
<i>PARAM</i>	69
<i>LIVING</i>	69
<i>TABLE</i>	68
<i>SURV</i>	68
<i>VARLEYLOG</i>	32
<i>VARLEY</i>	32
<i>EGGTREND</i>	32

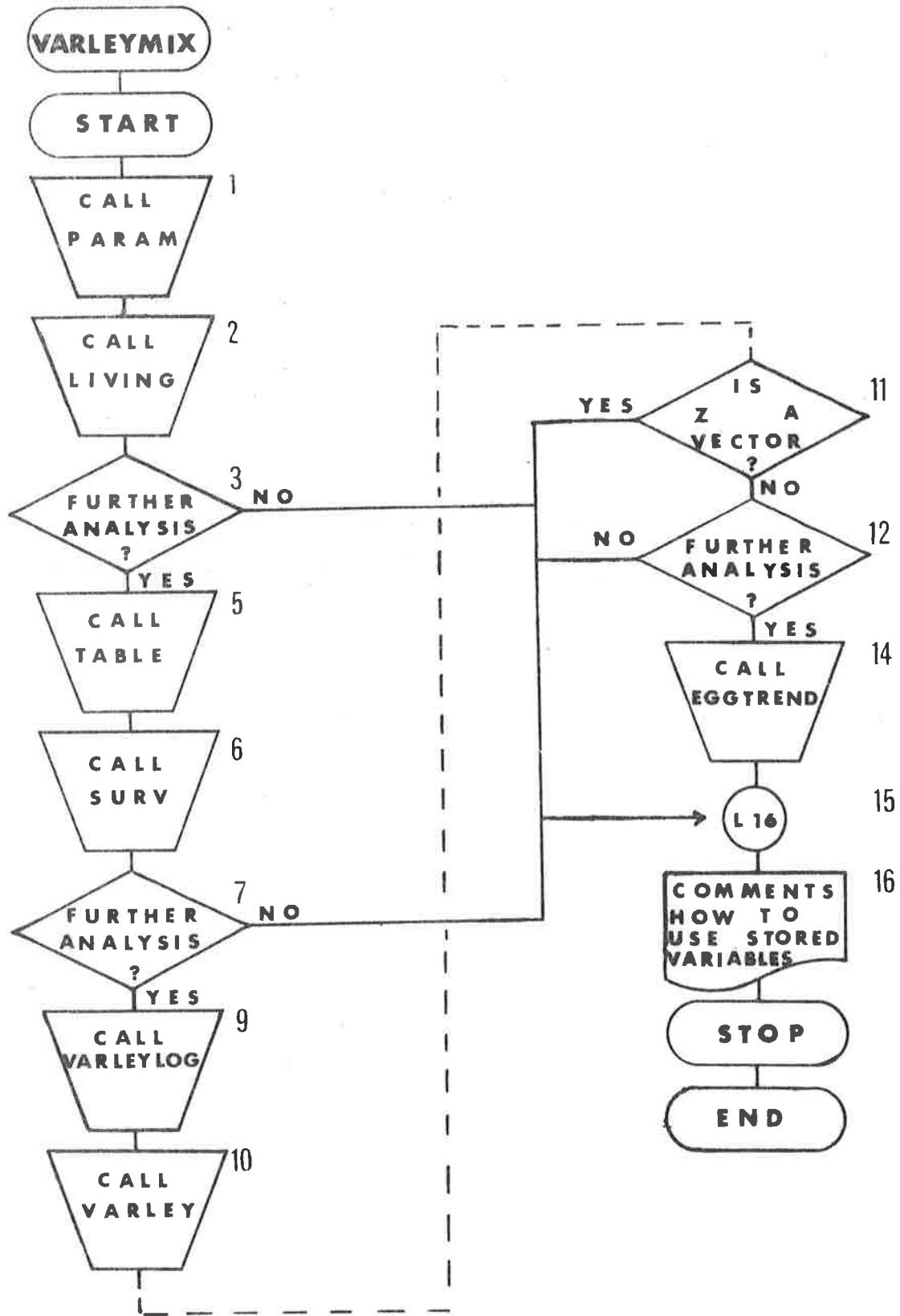
DESCRIPTIONS OF PROGRAMS

1. *Main Program VARLEYMIX*

Calls the sub programs PARAM, LIVING, TABLE, SURV, VARLEYLOG, VARLEY, and EGGTREND. Options are provided for printing results and exiting from program at 3 locations. The results are stored as global variables in the APL system if further analyses are required. The program operates in matrix mode (greater than 1 plot-year of basic data) or vector mode (1 plot-year of basic data). If the program is in vector mode, the sub program EGGTREND is bypassed. The numbers beside the boxes in the flow charts for this and the following programs refer to locations within the programs.

Main Program VARLEYMIX (Cont'd)

Flow Chart



Main Program VARLEYMIX (Cont'd)

The Program

```

▽ VARLEYMIX;REP
[1] PARAM
[2] LIVING
[3] →(L16×1^A/'NO'€REP←[]),0p[]←'FURTHER ANALYSES WITH THESE DA
TA ?'
[4] 2 2 p' '
[5] TABLE
[6] SURV
[7] →(L16×1^A/'NO'€REP←[]),0p[]←'FURTHER ANALYSES WITH THESE DA
TA ?'
[8] 2 2 p' '
[9] VARLEYLOG
[10] VARLEY
[11] →(((ppZ)[1])=1)/L16
[12] →(L16×1^A/'NO'€REP←[]),0p[]←'FURTHER ANALYSES WITH THESE DA
TA ?'
[13] 2 2 p' '
[14] EGGTREND
[15] L16: 5 2 p' '
[16] 'IF FURTHER OPERATIONS WITH YOUR DATA ARE DESIRED, THEY
ARE STORED :'
[17] ''
[18] '          DATA           GLOBAL VARIABLE'
[19] '          NO. OF LIVING'      ''
[20] '          INSECTS/SQ.M.        MOOSE'
[21] '          LOGE(10*5(N+1))'    ''
[22] '          INSECTS/SQ.M.        SPOCK'
[23] '          K FACTORS          GRADWELL'
[24] '          LOGE(10*5(N+1))'    ''
[25] '          SURVIVAL RATES       LOGSUR'
[26] '          LOGE(10*5(N+1))'    ''
[27] '          EGG POP. TRENDS      POP'
[28] 'STORAGE VALID FOR ONE PROGRAM PASS ONLY'
▽

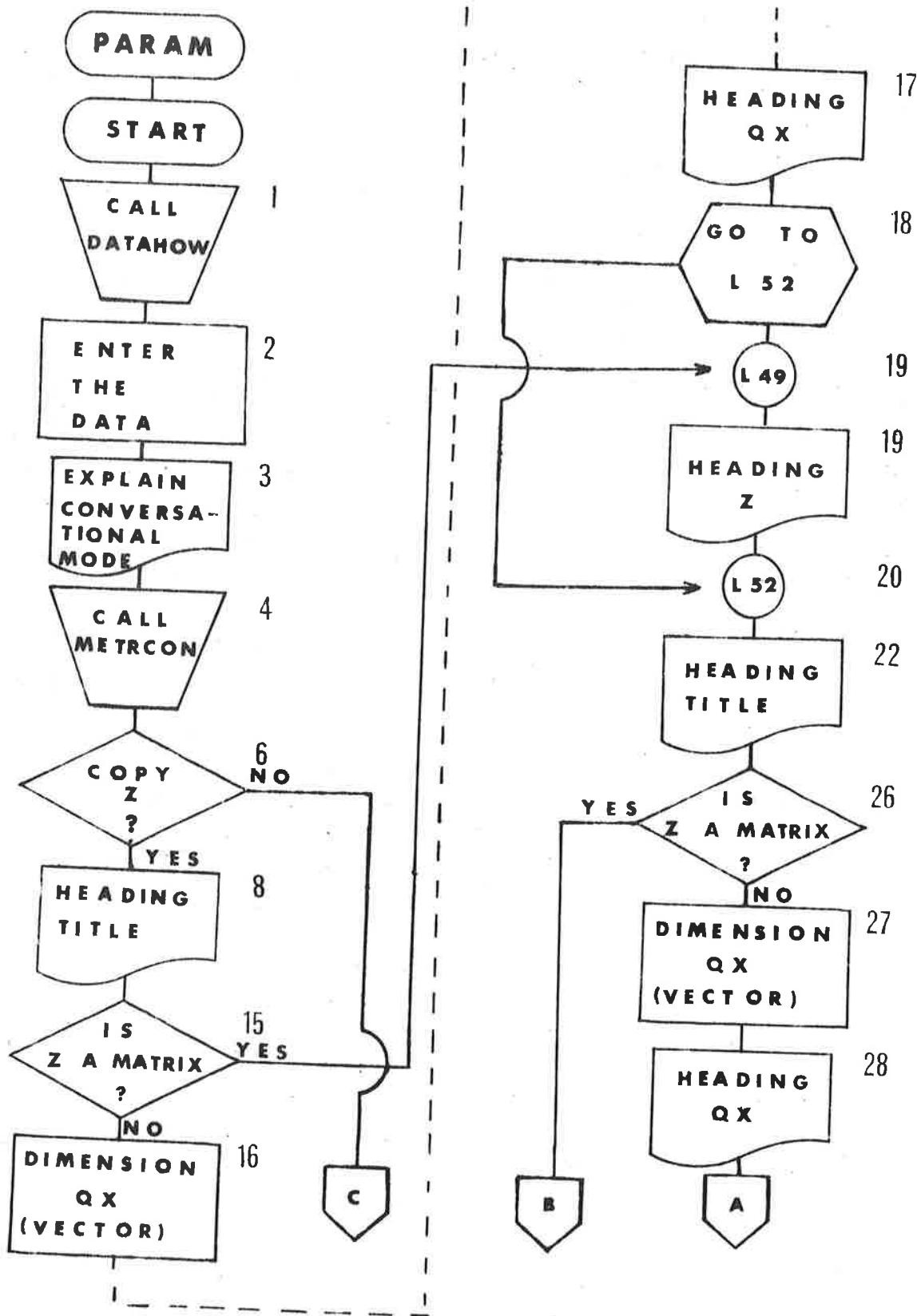
```

2. Sub Program PARAM

This program prints basic population data with headings. It utilises the sub-sub program METRCON. The basic data are obtained from Fortran IV printouts of data summaries. A manual of Fortran IV programs is in preparation.

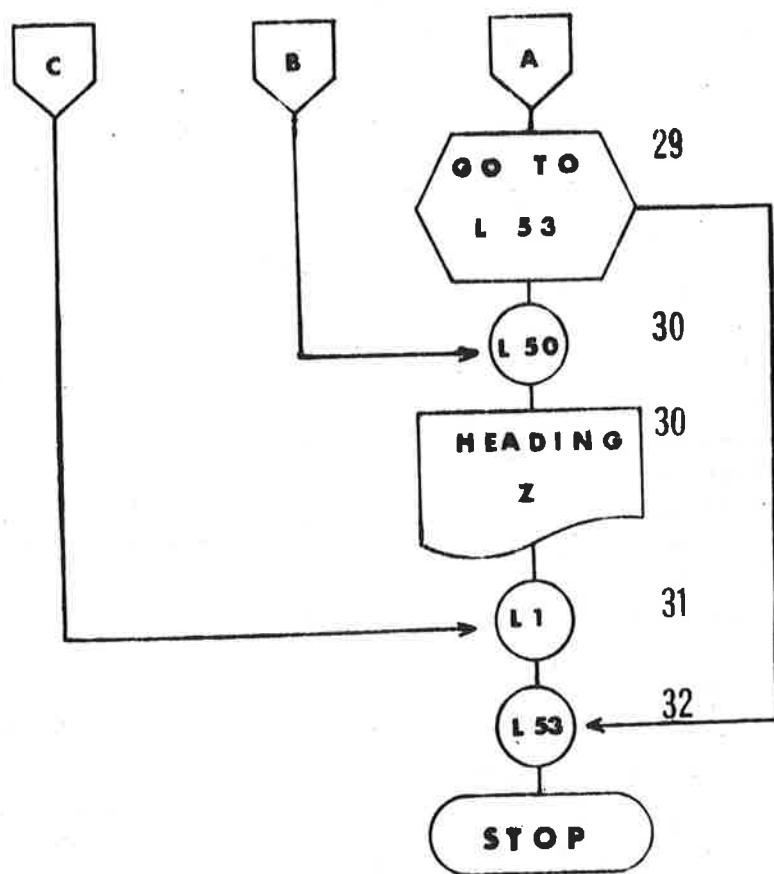
Sub Program PARAM (Cont'd)

Flow Chart



Sub Program PARAM (Cont'd)

Flow Chart



Sub Program PARAM (Cont'd)

The Program

```

    V PARAM;QX;REP
[1] DATAHOW
[2] Z←[]
[3] 'THE PROGRAM IS IN CONVERSATIONAL MODE: ANSWER YES OR NO
   TO THE QUESTIONS POSED'
[4] METRCON
[5] 2 2 p' '
[6] →(L1×1^/'NO'€REP←[]),0p[]←'COPY BASIC POPULATION DATA ?'
[7] 5 2 p' '
[8] 'BASIC POPULATION DATA'
[9] 2 2 p' '
[10] 'PLOT YEAR TREES      EGG      EGGS HATCHED MATURE EON
     YMPS COCOONS COCOONS'
[11] '          PER CLUSTERS      PER EGGS PER LARVAE
     PER      PER      PER'
[12] '          SQ.M. PER TREE CLUSTER CLUSTER      PER S
     QUARE  SQUARE  SQUARE'
[13] '          METRE METRE METRE'
[14] '          YEAR N  YEAR N  YEAR N  YEAR N  YEAR N  YEAR N  Y
     EAR N  YEAR N  YEAR N'
[15] →(((ppZ)[1])=2)/L49
[16] QX← 1 10 pZ↑10]
[17] 'I2,I7,F8.5,F9.2,F8.3,F9.2,F8.2,F9.2,2F8.2' ΔFMT QX
[18] →L52
[19] L49:'I2,I7,F8.5,F9.2,F8.3,F9.2,F8.2,F9.2,2F8.2' ΔFMT Z↑;1
     10]
[20] L52:10
[21] 5 2 p' '
[22] 'PLOT YEAR POTENTIAL      ACTUAL      SEX      EGG      TREES'
[23] '          FECUNDITY FECUNDITY RATIO CLUSTERS      PER
[24] '          PER TREE      SQ.M.'
[25] '          YEAR N+1 YEAR N  YEAR N+1  YEAR N+1'
[26] →(((ppZ)[1])=2)/L50
[27] QX← 1 7 pZ↑1,2,10+15]
[28] 'I2,I7,2F10.2,F7.3,F9.2,F10.5' ΔFMT QX
[29] →L53
[30] L50:'I2,I7,2F10.2,F7.3,F9.2,F10.5' ΔFMT Z↑;1,2,10+15]
[31] L1: 5 2 p' '
[32] L53: 5 2 p' '

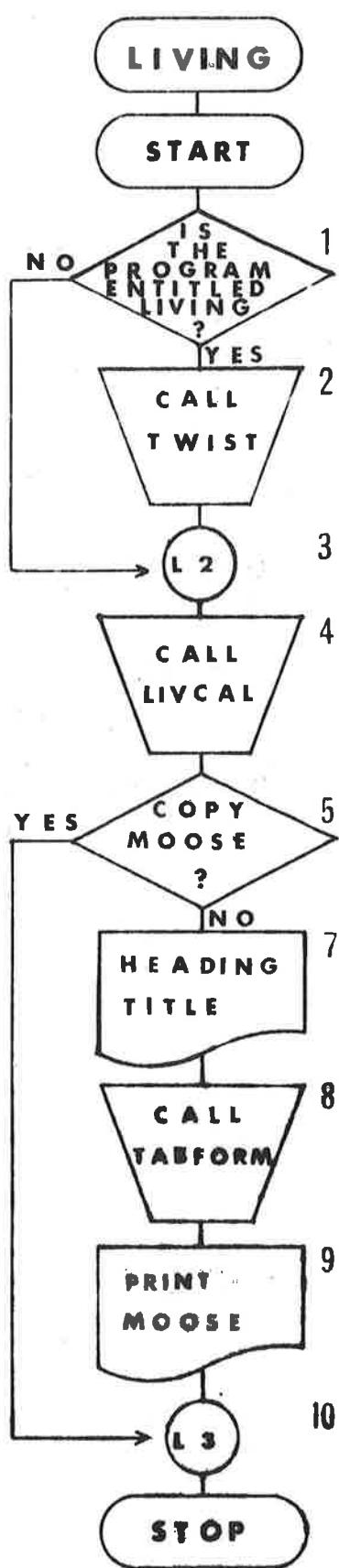
```

3. *Sub Program LIVING*

Calculates the number of living insects per sq. metre for 9 sawfly age intervals. It utilises the sub programs TWIST, LIVCAL, and TABFORM. The results are stored in the APL system under the global variable name MOOSE.

Sub Program LIVING (Cont'd)

Flow Chart



*Sub Program LIVING (Cont'd)**The Program*

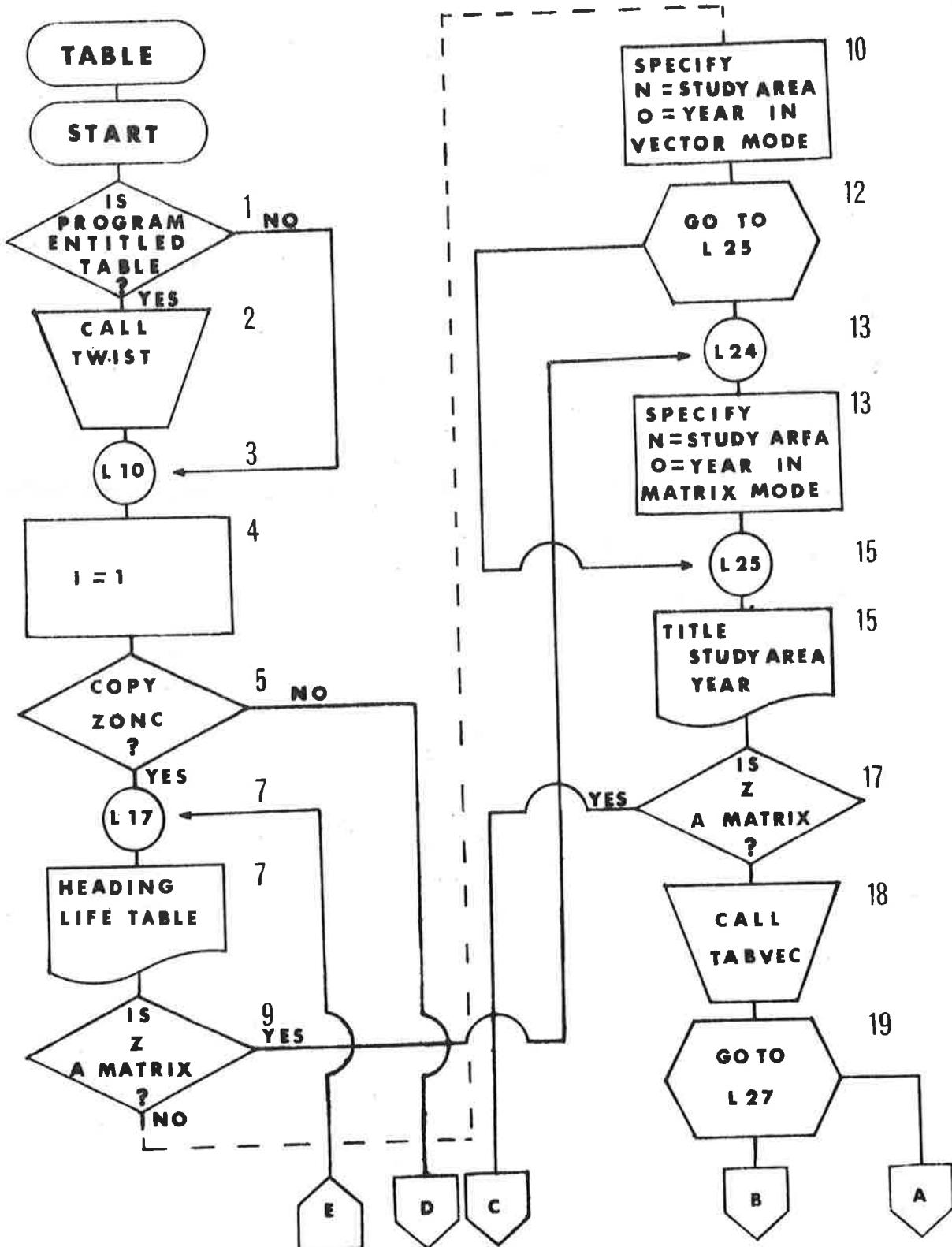
▽ LIVING;REP
[1] →(L2×1^/'NO'εREP←[],0p[]←'IS THE PROGRAM IN USE ENTITLED
LIVING?'
[2] TWIST
[3] L2: 5 2 p' '
[4] LIVCAL
[5] →(L3×1^/'NO'εREP←[],0p[]←'COPY NO. OF LIVING INSECTS PER
SQ. M.?'
[6] 5 2 p' '
[7] 'NO. OF LIVING INSECTS PER SQ. M.'
[8] TABFORM
[9] '2I6,9F10.5' ΔFMT MOOSE
[10] L3: 5 2 p' '
▽

4. *Sub Program TABLE*

Prints age specific life tables for 9 age intervals of the sawfly. It utilises the sub-sub programs TWIST, TABVEC, and TABMAT.

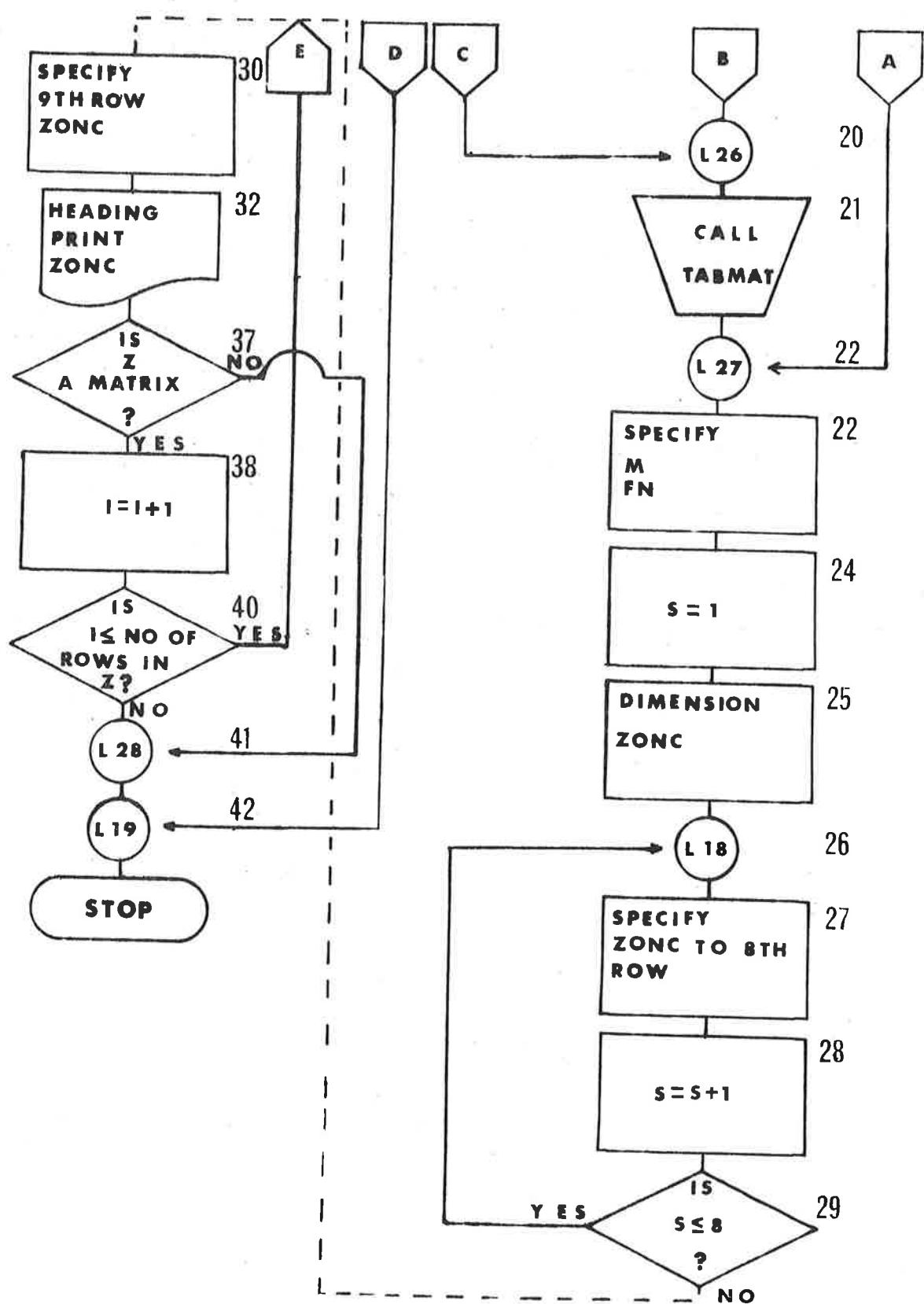
Sub Program TABLE (Cont'd)

Flow Chart



Sub Program TABLE (Cont'd)

Flow Chart



Sub Program TABLE (Cont'd)

The Program

```

▽ TABLE;A;B;C;D;E;F;G;H;I;J;K;L;M;N;O;S;FN;REP
[1] →(L10×1∧/'NO'εREP←¶),0o□←'IS THE PROGRAM IN USE ENTITLED
      TABLE?'
[2] TWIST
[3] L10: 5 2 p' '
[4] I←1
[5] →(L19×1∧/'NO'εREP←¶),0p□←'COPY LIFE TABLES?'
[6] 5 2 p' '
[7] L17:'LIFE TABLE'
[8]
[9] →(((ppZ)[1])=2)/L24
[10] N←Z[1]
[11] O←Z[2]
[12] →L25
[13] L24:N←Z[I;1]
[14] O←Z[I;2]
[15] L25:'STUDY AREA :';N
[16] '           YEAR :';O
[17] →(((ppZ)[1])=2)/L26
[18] TABVEC
[19] →L27
[20] L26:10
[21] TABMAT
[22] L27:M← 0 1 6 8 9 10 11 12 13
[23] FN←C,D,E,F,G,H,J,K,L
[24] S←1
[25] ZONC← 9 6 p0
[26] L18:→10
[27] ZONC[S;]←(M[S]),(FN[S]),((-FN[S+1])+(FN[S])),((((-FN[S+1])
      +(FN[S]))÷(FN[S]))×100),((FN[S+1])÷(FN[S])),(@(((FN[S+1])
      +(FN[S]))×10000))
[28] S←S+1
[29] →(S≤8)/L18
[30] ZONC[9;]←(M[9]),(L),((-L)+(C)),(((((-L)+(C))÷(C))×100),(L
      ÷C),(@((L÷C)×10000)))
[31] 2 2 p' '
[32] ' AGE          NUMBER        NUMBER        PERCENT      SURVIVAL
      LOGE(10E5)X'
[33] '           LIVING        DYING        MORTALITY     RATE
      SURVIVAL'
[34] '           PER          PER
      RATE'
[35] '           SQ. METRE    SQ. METRE'
[36] 'I4, X3,F9.4,X3,F9.4,X4,F8.2,X4,F8.5,X4,F8.6' ΔFMT ZONC
[37] →(((ppZ)[1])=1)/L28
[38] I←I+1
[39] 5 2 p' '
[40] →(I≤pZ[1])/L17
[41] L28:10
[42] L19:10
▽

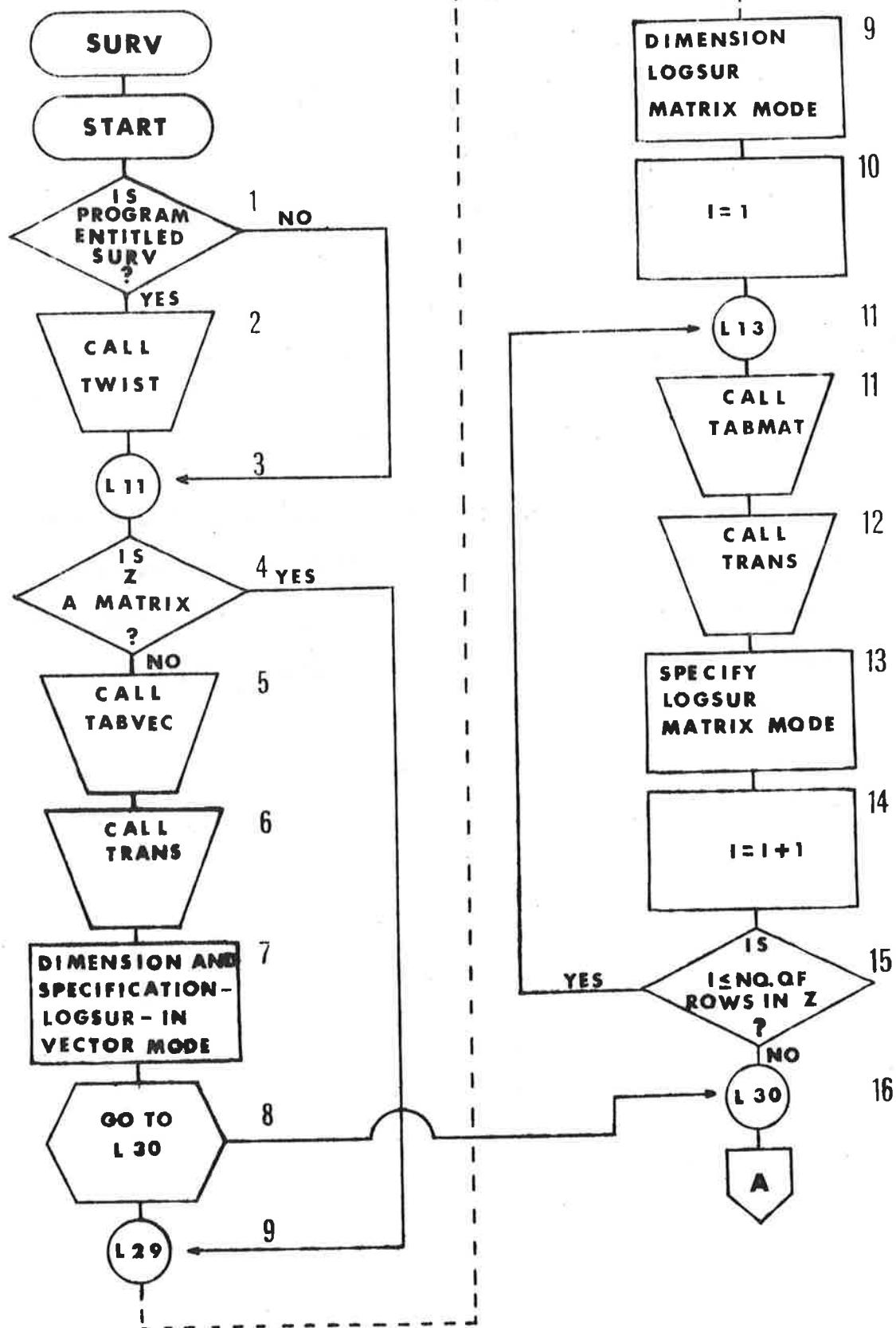
```

5. Sub Program SURV

Calculates $\log_e (10^5 \times N)$ where N = the survival rate, for 9 sawfly age intervals. The factor 10^5 is to eliminate negative logarithms. It utilises the sub-sub programs TWIST, TABVEC, TRANS, TABMAT and TABFORM. The results are stored under the global variable name LOGSUR.

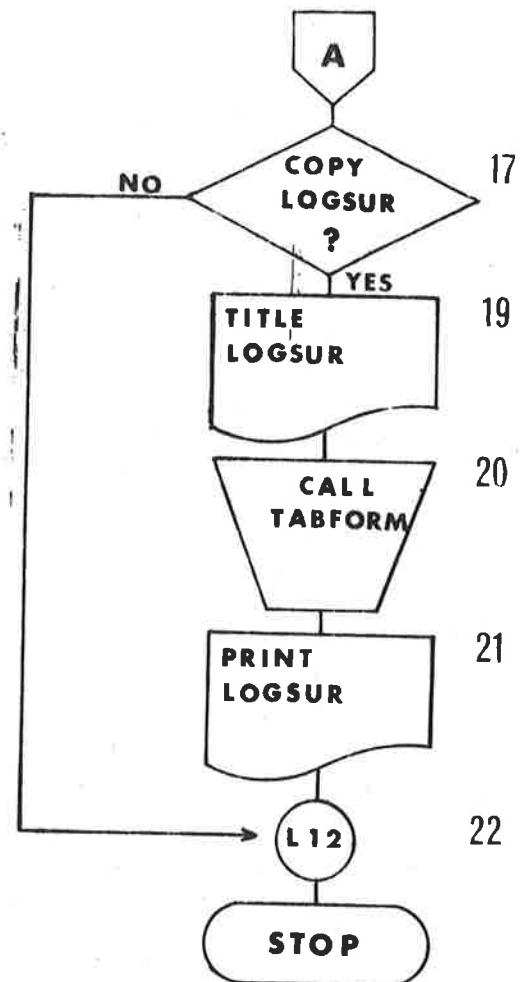
Sub Program SURV (Cont'd)

Flow Chart



Sub Program SURV (Cont'd)

Flow Chart



*Sub Program SURV (Cont'd)**The Program*

```

    ▽ SURV;A;B;C;D;E;F;G;H;I;J;K;L;P;REP
[1] →(L11×1^/'NO'εREP←M),0p[]←'IS THE PROGRAM IN USE ENTITLED
     SURV ?'
[2] TWIST
[3] L11: 5 2 p' '
[4] →((p p Z)[1])=2)/L29
[5] TABVEC
[6] TRANS
[7] LOGSUR← 1 11 p(Z'1 2]),(P)
[8] →L30
[9] L29:LOGSUR←(((p Z)[1]),11)p0
[10] I←1
[11] L13:TABMAT
[12] TRANS
[13] LOGSUR(I;1←(Z(I; 1 2]),(P)
[14] I←I+1
[15] →(I≤p Z;1])/L13
[16] L30:10
[17] →(L12×1^/'NO'εREP←M),0p[]←'COPY LOGE(10E5(N+1)) SURVIVAL
     RATES ?'
[18] 5 2 p' '
[19] 'LOGE(10E5(N+1)) SURVIVAL RATES '
[20] TABFORM
[21] '2I6,3F10.6' ΔFMT LOGSUR
[22] L12: 5 2 p' '
    ▽

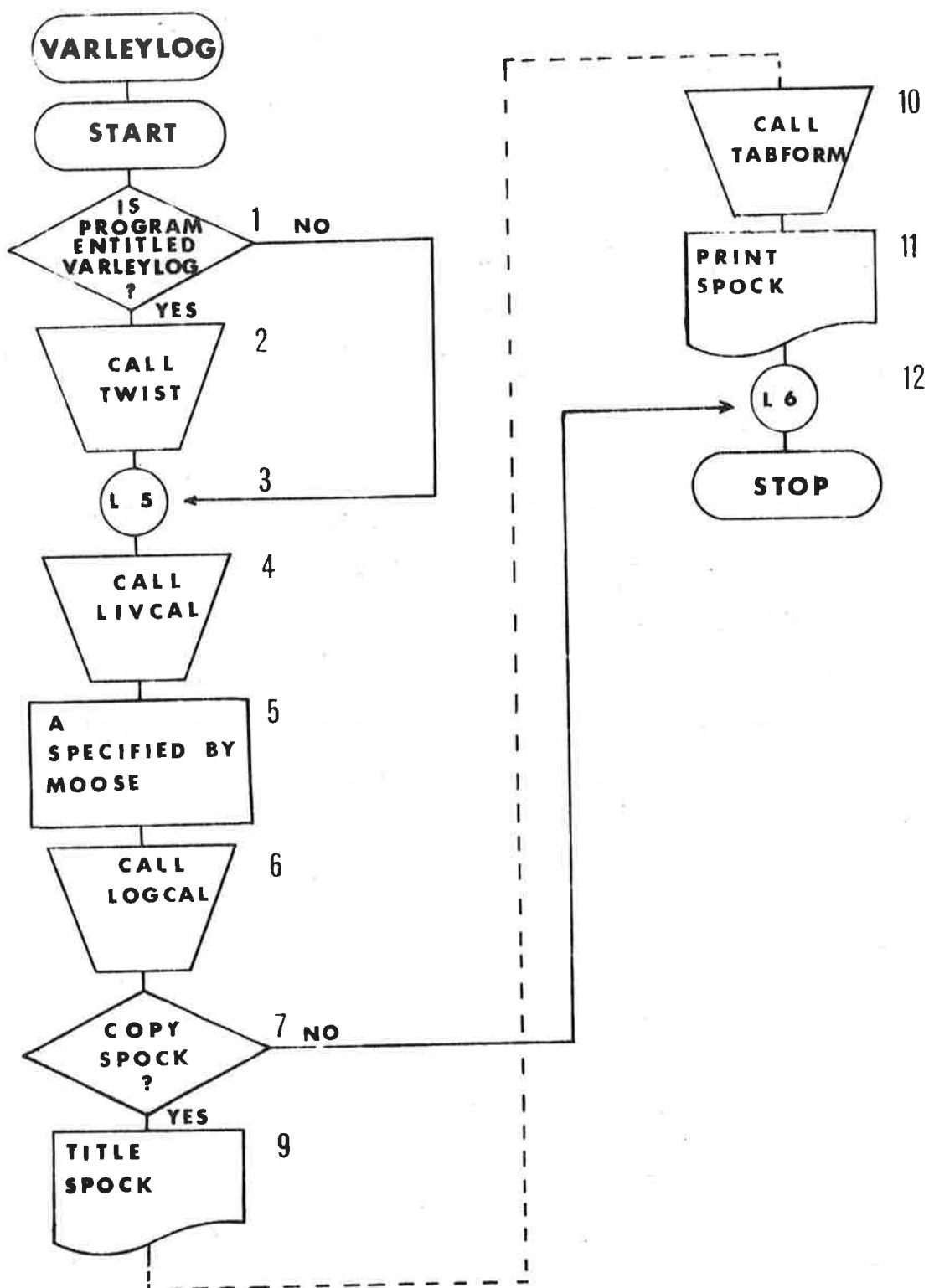
```

6. Sub Program VARLEYLOG

Calculates the logarithmic transformations of $\log_e (10^5 \times (N + 1))$ where N = the number of living insects per sq. metre. The factor 10^5 is to eliminate negative logarithms and $N + 1$ is an adjustment for the logarithms of zero entries. It utilises the sub programs TWIST, LIVCAL, LOGCAL, and TABFORM. The results are stored under the global variable name SPOCK.

Sub Program VARLEYLOG (Cont'd)

Flow Chart



*Sub Program VARLEYLOG (Cont'd)**The Program*

```

    ▽ VARLEYLOG;A;B;D;REP
[1] →(L5×1^/'NO'€REP←[],0p[]+'IS THE PROGRAM IN USE ENTITLED
     VARLEYLOG ?'
[2] TWIST
[3] L5: 5 2 p' '
[4] LIVCAL
[5] A←MOOSE
[6] LOGCAL
[7] →(L6×1^/'NO'€REP←[],0p[]+'COPY LOGE(10,000(N+1)) NO. OF I
     NSECTS PER SQ: M. ?'
[8] 5 2 p' '
[9] 'LOGE(10*5(N+1)) NO. OF LIVING INSECTS PER SQ. M.'
[10] TABFORM
[11] '2I6,9F10.6' ΔEFT SPOCK
[12] L6: 5 2 p' '
    ▽

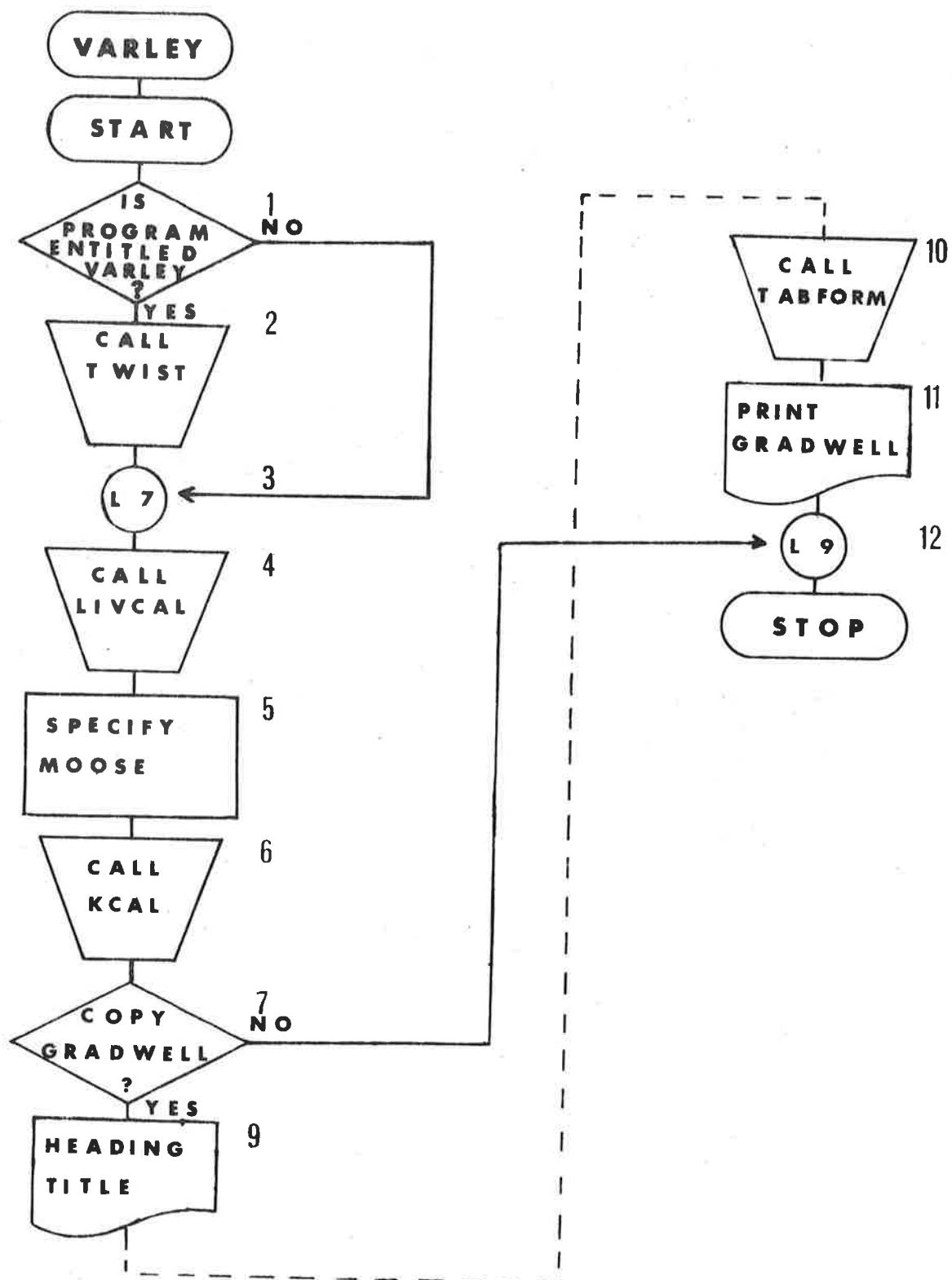
```

7. Sub Program VARLEY

Calculates Varley and Gradwell k-factors. It utilises the sub-sub programs TWIST, LIVCAL, KCAL and TABFORM. The results are stored under the global variable name GRADWELL.

Sub Program VARLEY (Cont'd)

Flow Chart



Sub Program VARLEY (Cont'd)

The Program

```

    ▽ VARLEY;A;B;D;I;G;L;REP
[1] →(L7×1^/'NO'εREP←[],0p□←'IS THE PROGRAM IN USE ENTITLED
     VARLEY ?'
[2] TWIST
[3] L7: 5 2 p' '
[4] LIVCAL
[5] A←MOOSE
[6] KCAL
[7] +(L9×1^/'NO'εREP←[],0p□←'COPY ''K'' FACTORS ?'
[8] 5 2 p' '
[9] 'VARLEY AND GRADWELL K FACTORS'
[10] TABFORM
[11] '2I6,9F10.6' ΔFMT GRADWELL
[12] L9: 5 2 p' '
    ▽

```

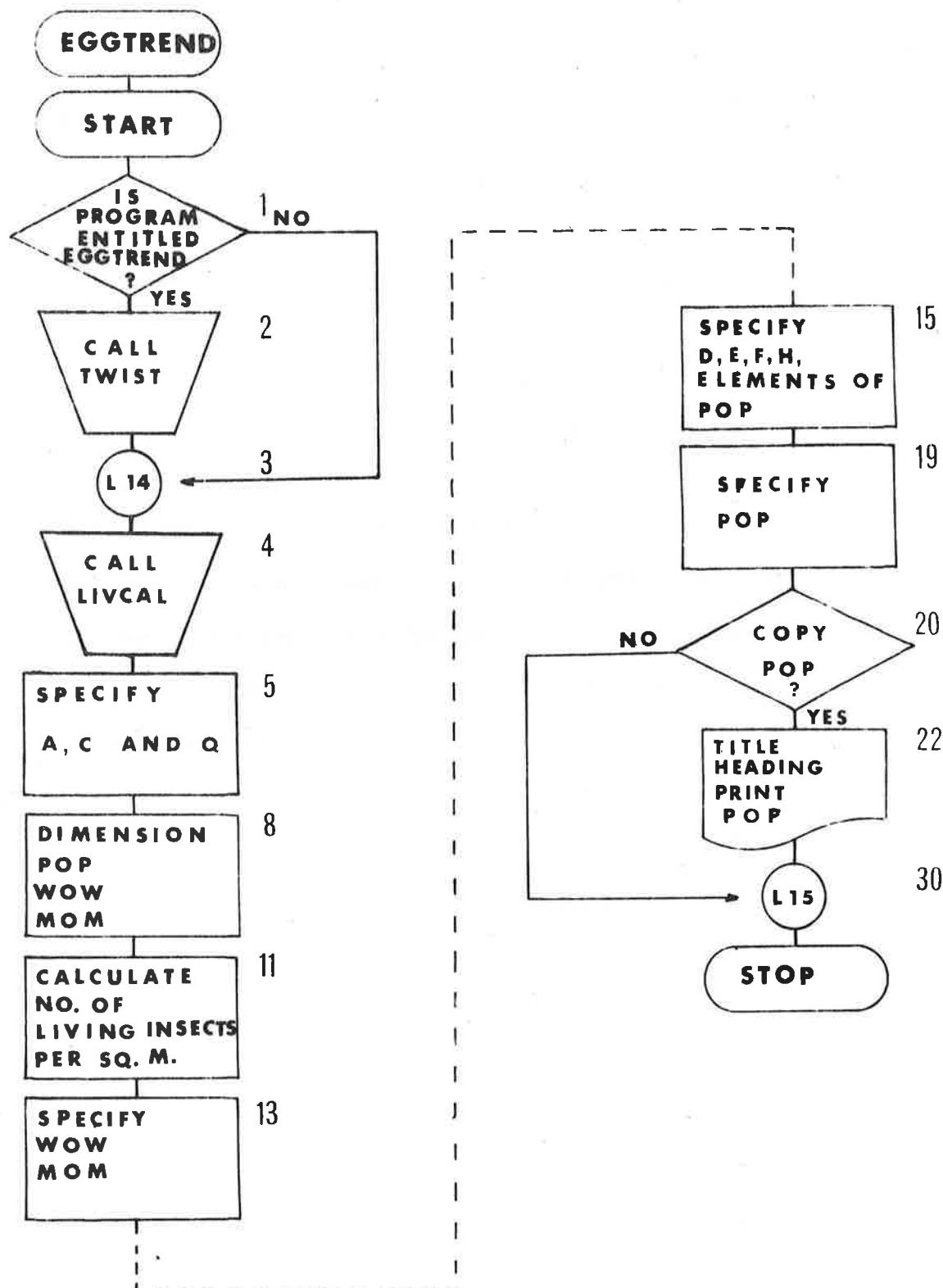
8. Sub Program EGGTREND

Computes an $N \times 2$ matrix where the rows (N) = the number of plot-years and the columns are the logarithmic transformations (as in the sub program VARLEYLOG) of the number of sawfly eggs per sq. metre in year N vs. the number in year $N + 1$. It utilises the sub-sub programs TWIST and LIVCAL. The results are stored under the global variable name POP.

Sub Program EGGTREND (Cont'd)

30

Flow Chart



Sub Program EGGTREND (Cont'd)

The Program

```

▽ EGGTREND;A;B;C;Q;R;REP;D;H;E;F;MOM;WOW
[1] →(L14×1^/'NO'εREP←[],0p[]←'IS THE PROGRAM IN USE ENTITLED
      EGGTREND ?'
[2] TWIST
[3] L14: 5 2 p' '
[4] LIVCAL
[5] A←MOOSE
[6] C←A[, 3 4]
[7] Q←A[, 3]
[8] POP←(((pA)[1]),4)p0
[9] WOW←(((pA)[1]),2)p0
[10] MOM←(((pA)[1]),1)p0
[11] B←(⊗((C×10000)+1))
[12] R←(⊗((Q×10000)+1))
[13] WOW←B
[14] MOM←R
[15] D←A[, 1 3]
[16] H←((pD)-1)↑D
[17] E←((pWOW)-1)↑WOW
[18] F←1↑MOM
[19] POP←H,E,F
[20] →(L15×1^/'NO'εREP←[],0p[]←'COPY LOGE(10*5(N+1)) EGG POPUL
      ATION TRENDS ?'
[21] 5 2 p' '
[22] 'LOGE(10*5(N+1)) EGG POPULATION TRENDS'
[23] 3 2 p' '
[24] '
[25] '
[26] '
[27] '
[28] 'PLOT          YEAR          YEAR N          YEAR N+1'
[29] 'I4,X10,I4,X10,1F10.6,X4,1F10.6' ΔFMT POP
[30] L15: 5 2 p' '
▽

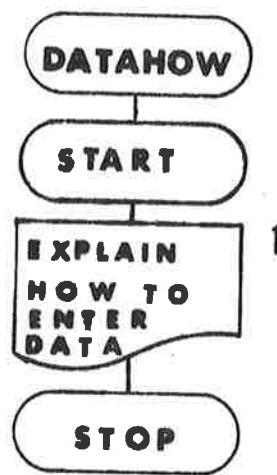
```

9. Sub-Sub Program DATAHOW

Lists for the equivalent study area number, the variable names
for the basic population matrices.

Sub-Sub Program DATAHOW (Cont'd)

Flow Chart



*Sub-Sub Program DATAHOW (Cont'd)**The Program*

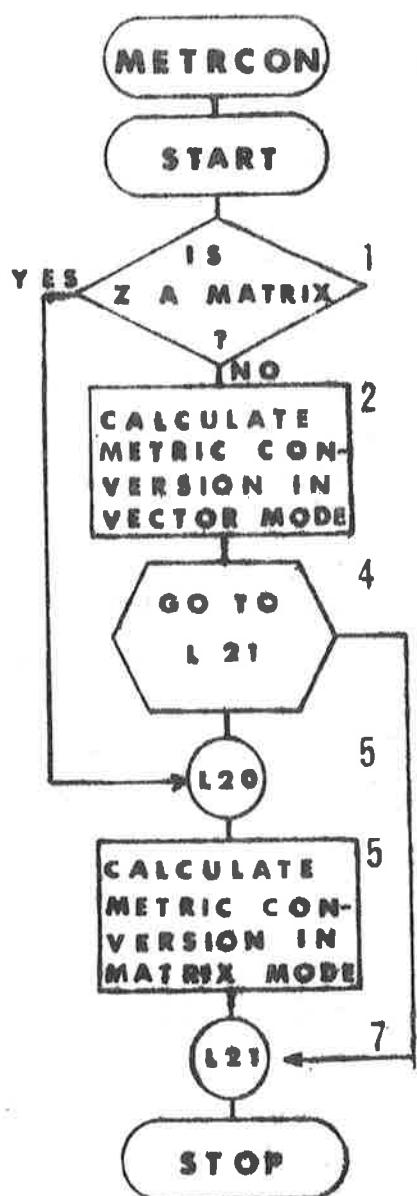
```
▽ DATAHOW
[1]  'ENTER BELOW THE APPROPRIATE BASIC POPULATION DATA :'
[2]  2 2 p '
[3]  '      VARIABLE      STUDY'
[4]  '                      AREA'
[5]  '      NAME          NUMBER'
[6]  '      ;17p'-
[7]  '          MCL          1'
[8]  '          ORISK         2'
[9]  '          IROQ          3'
[10] '          RIVMAR        4'
[11] '          CAOUS         5'
[12] '          CHEV          6'
[13] '          BAUDE         7'
▽
```

10. *Sub-Sub Program* METRCON

Calculates the metric conversions for the basic population data which are in English units. It is used in the sub program PARAM, and in the sub-sub program TWIST.

Sub-Sub Program METRCON (Cont'd)

Flow Chart

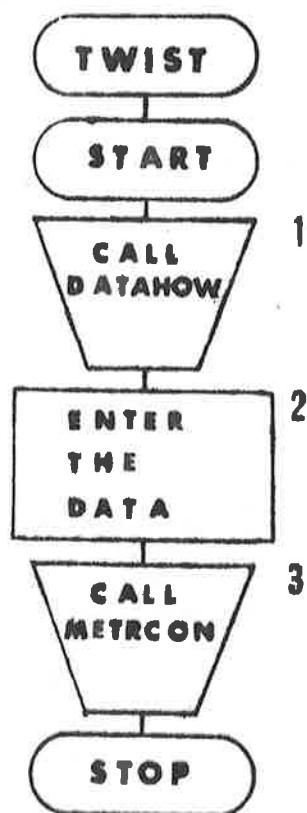


*Sub-Sub Program METRCON (Cont'd)**The Program*

▼ METRCON
[1] →(((ppZ)[1])=2)/L20
[2] Z[3 15]←Z[3 15]+4046.85468
[3] Z[7+10]+Z[7+10]+0.09290304000000001
[4] →L21
[5] L20:Z[3 15]+Z[3 15]+4046.85468
[6] Z[7+10]+Z[7+10]+0.09290304000000001
[7] L21:10
▼

11. Sub-Sub Program TWIST

Explains how to enter the basic population data, provides a space for the entry, and calculates the metric conversions. It utilises the sub-sub programs DATAHOW and METRCON and is used in the sub program LIVING, TABLE, SURV, VARLEYLOG, VARLEY and EGGTREND.

*Sub-Sub Program TWIST (Cont'd)**Flow Chart*

*Sub-Sub Program TWIST (Cont'd)**The Program*

▽ *TWIST*
[1] *DATAHOW*
[2] *Z+□*
[3] *METRCON*
▽

12. Sub-Sub Program LIVCAL

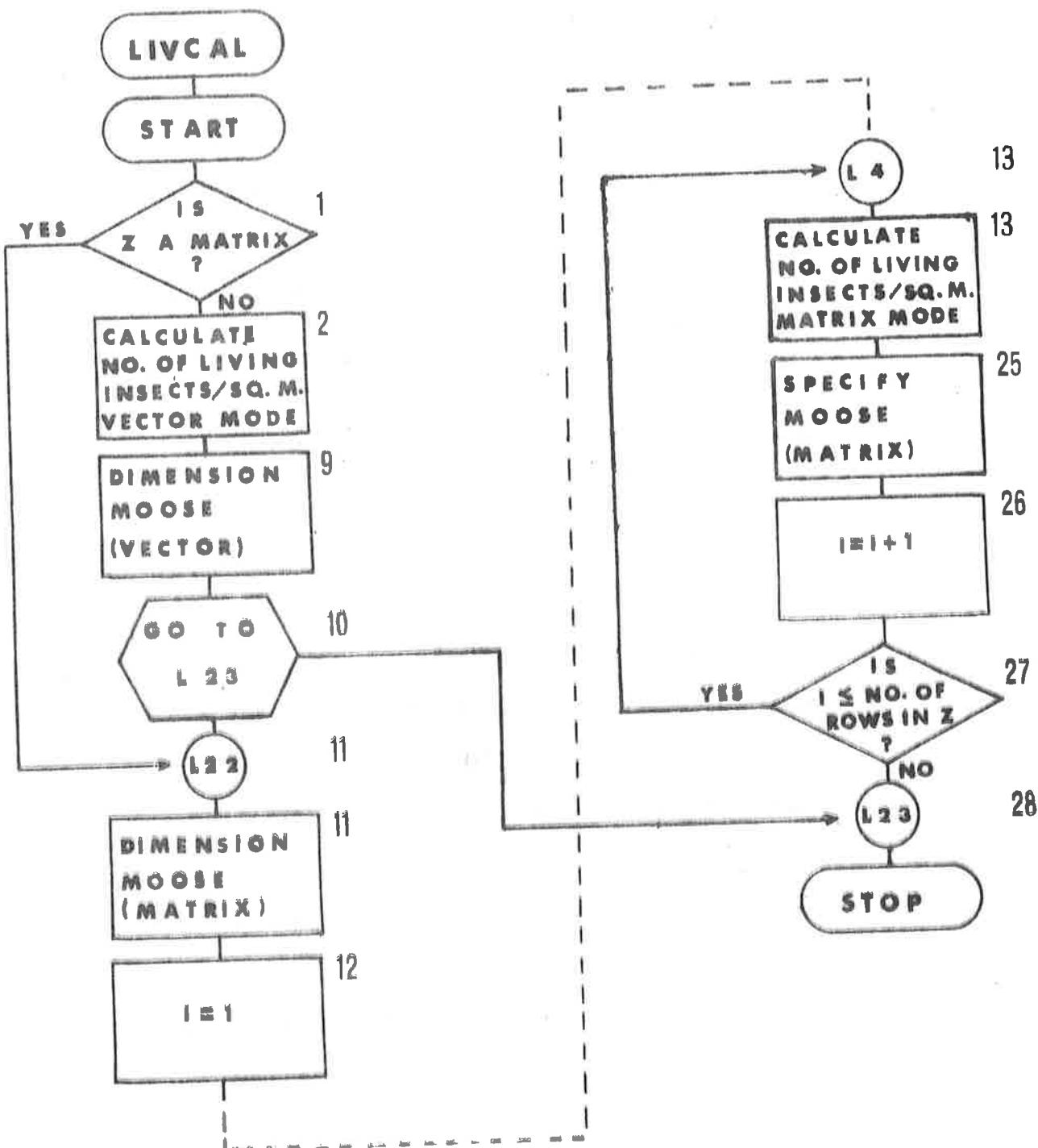
Calculates the number of living insects per sq. metre and is used in the sub programs LIVING, VARLEYLOG, and VARLEY. An explanation of the calculations follows:

Local Variable

<i>in Program</i>	<i>Explanation</i>
A	Trees per sq. metre (<i>YEAR N</i>) \times egg clusters per tree (<i>YEAR N</i>)
B	Trees per sq. metre (<i>YEAR N + 1</i>) \times egg clusters per tree (<i>YEAR N + 1</i>)
C	Eggs per sq. metre = A \times eggs per cluster (<i>YEAR N</i>)
D	Hatched eggs per sq. metre = A \times hatched eggs per sq. metre (<i>YEAR N</i>)
E	Mature larvae per sq. metre = A \times mature larvae per cluster (<i>YEAR N</i>)
F	Eonymphs per sq. metre (<i>YEAR N</i>)
G	Cocoons per sq. metre (fall) (<i>YEAR N</i>)
H	Cocoons per sq. metre (spring) (<i>YEAR N</i>)
J	Number of surviving sawfly adults = B + sex ratio (<i>YEAR N</i>)
K	Number of surviving sawfly females per sq.m. (<i>YEAR N</i>) = B
L	Adjustment for fecundity = B \times actual fecundity (<i>YEAR N + 1</i>) + potential fecundity

Sub-Sub Program LIVCAL (Cont'd)

Flow Chart



Sub-Sub Program LIVCAL (Cont'd)

The Program

```

    ▽ LIVCAL;A;B;C;E;F;D;G;H;I;J;K;L;FN
[1] →(((ρρZ)[1])=2)/L22
[2] A←Z[3]×Z[4]
[3] B←Z[15]×Z[14]
[4] C←A×Z[5]
[5] D←A×Z[6]
[6] E←A×Z[7]
[7] F←B÷Z[13]
[8] G←Z[12]×B÷Z[11]
[9] MOOSE← 1 11 ρZ[1 2],C,D,E,Z[8 9 10],F,B,G
[10] →L23
[11] L22:MOOSE←(((ρZ)[1]),11)ρ0
[12] I←1
[13] L4:A←Z[I;3]×Z[I;4]
[14] B←Z[I;15]×Z[I;14]
[15] C←A×Z[I;5]
[16] D←A×Z[I;6]
[17] E←A×Z[I;7]
[18] F←Z[I;8]
[19] G←Z[I;9]
[20] H←Z[I;10]
[21] J←B÷Z[I;13]
[22] K←B
[23] L←Z[I;12]×B÷Z[I;11]
[24] FN←C,D,E,F,G,H,J,K,L
[25] MOOSE[I;]←Z[I; 1 2],FN
[26] I←I+1
[27] →(I≤ρZ[;1])/L4
[28] L23:10
    ▽

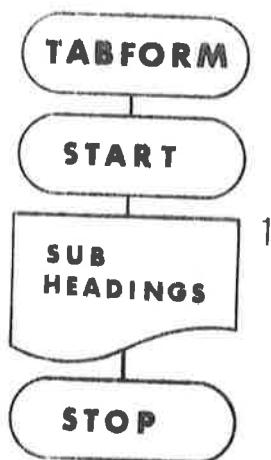
```

13. Sub-Sub Program TABFORM

Prints the headings for the 9 sawfly age intervals. It is used
in the sub programs LIVING, SURV, VARLEYLOG and VARLEY.

Sub-^{S 1} Program TABFORM (Cont'd)

Flow Chart



Sub-Sub Program TABFORM (Cont'd)

The Program

```

    V TABFORM
[1] 2 2 p' '
[2]
[3] AL'
[4]   9      10      0      1      12      6      8
[5] 105p'-'
[6] PLOT  YEAR  EGGS  HATCHED  MATURE  EONYME'S  C
[7] COCOONS  COCOONS  ADULTS  FEMALES  ADJUSTMENT'
[8]          EGGS  LARVAE
[9]          FALL  SPRING  FOR FECUNDITY'
[10]          (GENERATION)'

    V

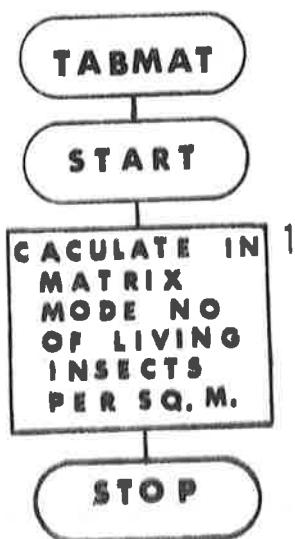
```

14. Sub-Sub Program TABMAT

Calculates the number of living insects per sq. metre for 9 sawfly age intervals in matrix mode. It is used in sub programs LIVING and SURV.

Sub-Sub Program TABMAT (Cont'd)

Flow Chart



Sub-Sub Program TABMAT (Cont'd)

The Program

```

    V TABMAT
[1] A+Z[I;3]*Z[I;4]
[2] B+Z[I;15]*Z[J;14]
[3] C=A*X[Z[I;5]
[4] D=A*X[Z[I;6]
[5] E=A*X[Z[I;7]
[6] F+Z[I;3]
[7] G+Z[I;9]
[8] H+Z[I;10]
[9] J=B+Z[I;13]
[10] K+B
[11] L+Z[I;12]*B+Z[I;11]

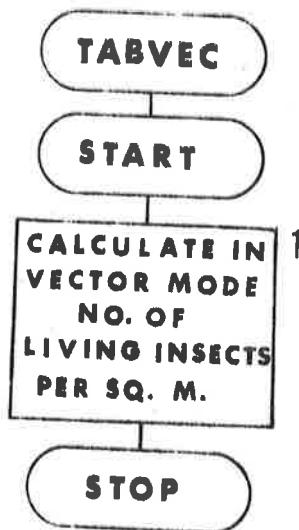
```

15. Sub-Sub Program TABVEC

The calculations are identical to TABMAT except that they are in vector mode. Used in sub programs LIVING and SURV.

Sub-Sub Program TARVEC (Cont'd)

Flow Chart



*Sub-Sub Program TABVEC (Cont'd)**The Program*

▽ TABVEC
[1] $A \leftarrow Z[3] \times Z[4]$
[2] $B \leftarrow Z[15] \times Z[14]$
[3] $C \leftarrow A \times Z[5]$
[4] $D \leftarrow A \times Z[6]$
[5] $E \leftarrow A \times Z[7]$
[6] $F \leftarrow Z[8]$
[7] $G \leftarrow Z[9]$
[8] $H \leftarrow Z[10]$
[9] $J \leftarrow B \div Z[13]$
[10] $K \leftarrow B$
[11] $L \leftarrow Z[12] \times B \div Z[11]$

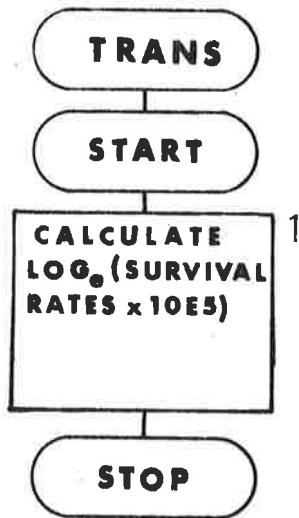
▽

16. *Sub-Sub Program TRANS*

Calculates the natural logarithm of the survival rates for each of 9 sawfly age intervals. The survival rates are multiplied by 10^5 to eliminate negative logarithms. It is used twice in the sub program TABLE.

Sub-Sub Program TRANS (Cont'd)

Flow Chart



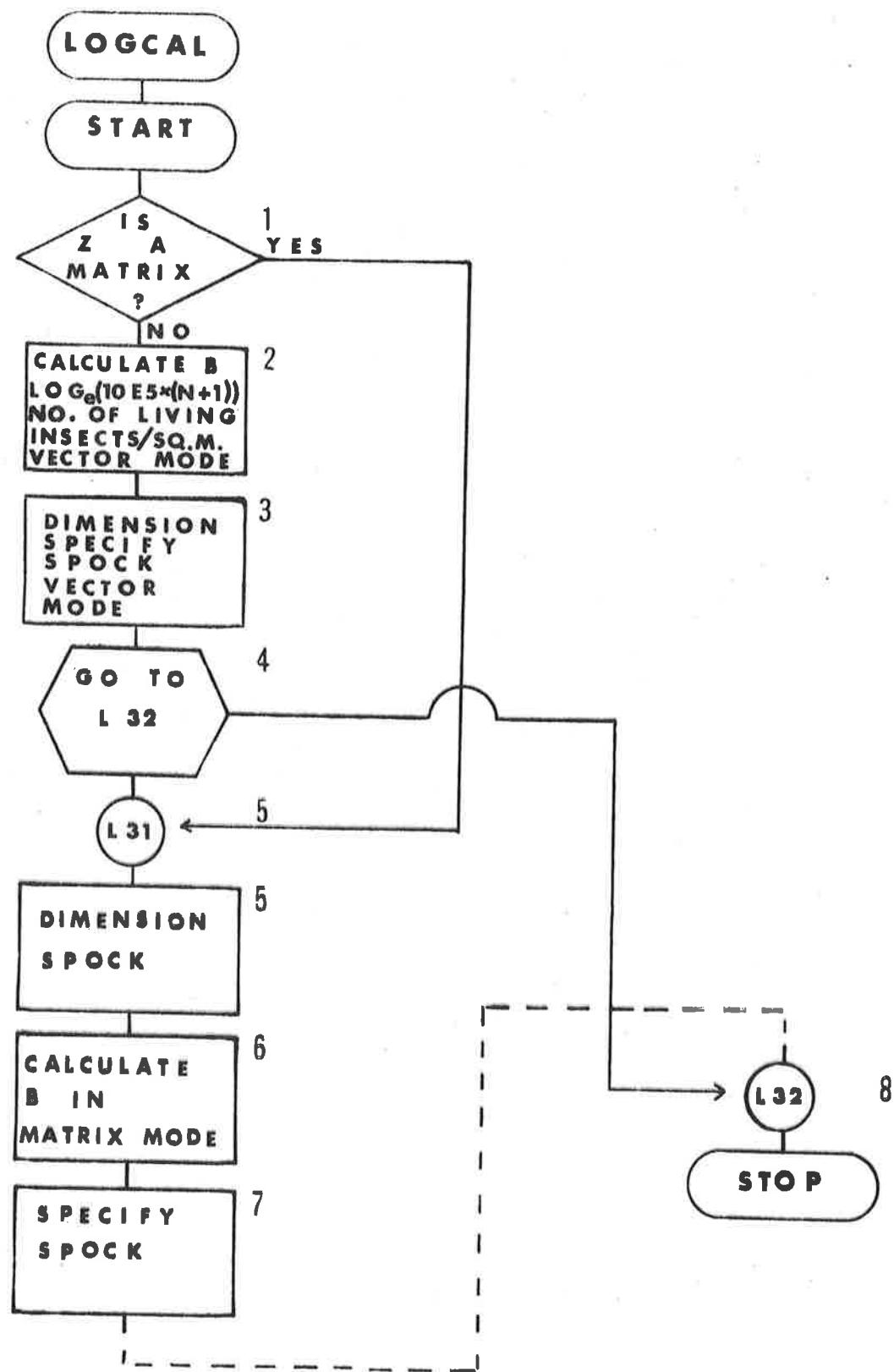
*Sub-Sub Program TRANS (Cont'd)**The Program*

V TRANS
[1] $P \leftarrow (\oplus((D+G) \times 10000)), (\oplus((E+D) \times 10000)), (\oplus((F+E) \times 10000)), (\oplus((G+F) \times 10000)), (\oplus((H+G) \times 10000)), (\oplus((J+H) \times 10000)), (\oplus((K+J) \times 10000)), (\oplus((L+K) \times 10000)), (\oplus((L+G) \times 10000))$

17. Sub-Sub Program LOGCAL

Calculates $\log_e (10^5 \times (N + 1))$ where N = the number of living insects per sq. metre in matrix as well as in vector mode. It is used in the sub program VARLEYLOG.

Flow Chart



*Sub-Sub Program LOGCAL (Cont'd)**The Program*

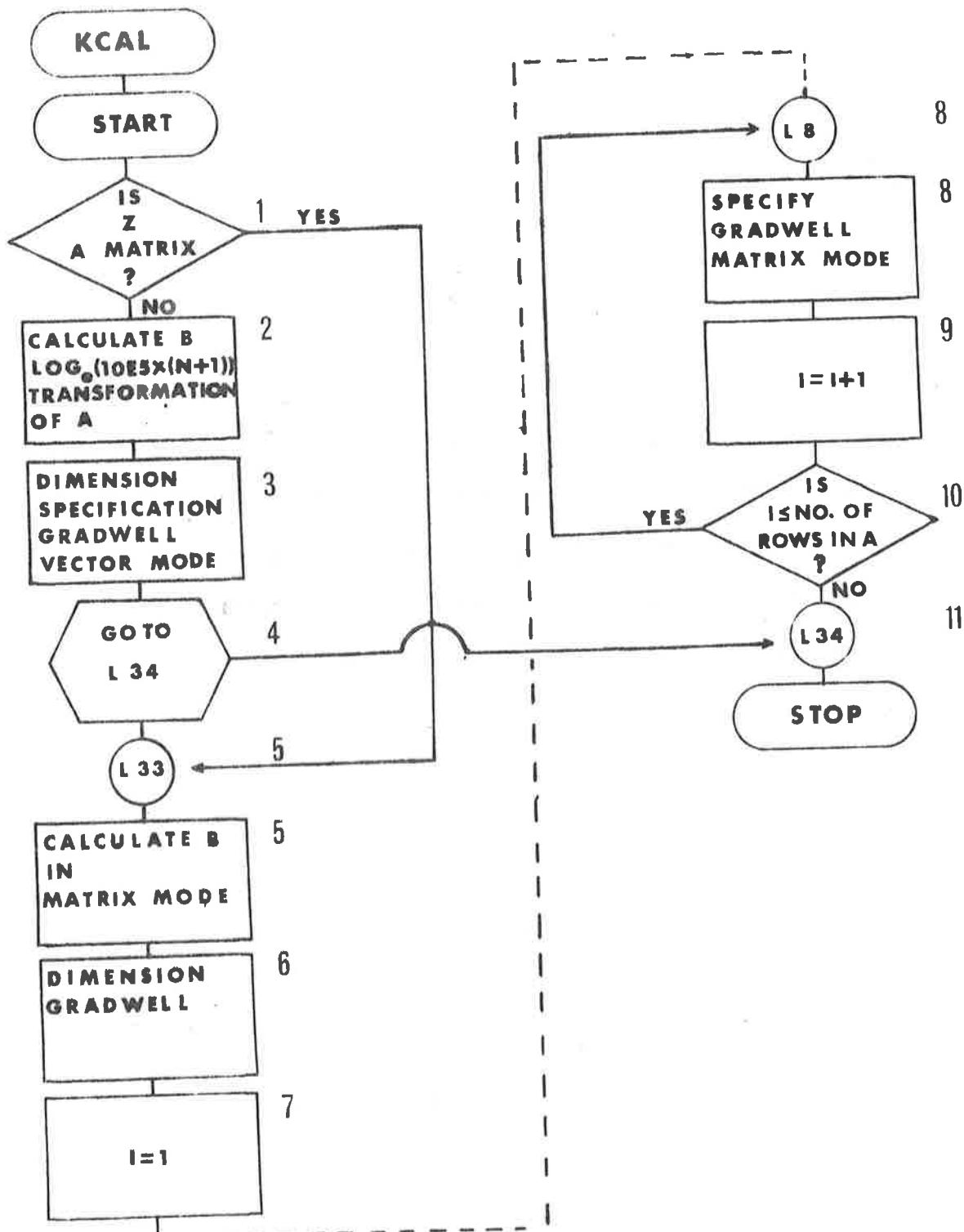
```
    V LOGCAL
[1]  →(((ppZ)[1])=2)/L31
[2]  B←(⊖(A[1;2↓;11]×10000)+1)
[3]  SPOCK+ 1 11 pA[1;12],B
[4]  →L32
[5]  L31:SPOCK+((pA)[1]),9)p0
[6]  B←(⊖(A[1;2↓;11]×10000)+1)
[7]  SPOCK+A[1;12],B
[8]  L32:10
    V
```

18. Sub-Sub Program KCAL

Calculates Varley and Gradwell k-factors in vector as well as in matrix mode. The operation consists in subtracting $\log_e (N + 1)$ no. of living insects per sq. metre in age interval $A + 1$ from $\log_e (N + 1)$ no. of living insects per sq. metre in age interval A for each sawfly age interval. It is used in the sub program VARLEY.

Sub-Sub Program KCAL (Cont'd)

Flow Chart



*Sub-Sub Program KCAL (Cont'd)**The Program*

```

    ▽ KCAL
[1]  +(((p0Z)[1])=2)/L33
[2]  B←((A[1;2+11]*10000)+1)
[3]  GRADWELL← 1 11 p(A[1;12]),(B[1]-B[2]),(B[2]-B[3]),(B[3]-B[4]),
     ,(B[4]-B[5]),(B[5]-B[6]),(B[6]-B[7]),(B[7]-B[8]),(B[8]-B[9]),
     ,(B[1]-B[9])
[4]  →L34
[5]  L33:B←((A[1;2+11]*10000)+1)
[6]  GRADWELL←(((pA)[1]),11)p0
[7]  I←1
[8]  L8:GRADWELL[I;]←(A[I;12]),(B[I;1]-B[I;2]),(B[I;2]-B[I;3])
     ,(B[I;3]-B[I;4]),(B[I;4]-B[I;5]),(B[I;5]-B[I;6]),(B[I;6]
     -B[I;7]),(B[I;7]-B[I;8]),(B[I;8]-B[I;9]),(B[I;1]-B[I;9])
[9]  I←I+1
[10] →(I≤6A[1])/L8
[11] L34:i0
    ▽

```

A SPECIMEN PROGRAM

The printout of the main program VARLEYMIX in matrix mode is shown on the following pages. Two plot-years, 1962 and 1963, from Study Area 4 have been selected for illustration.

VARLEYMX
ENTER BELOW THE APPROPRIATE BASIC POPULATION DATA :

VARIABLE	STUDY AREA NUMBER
MCL	1
ORISK	2
IROQ	3
RIVMAR	4
CAOUS	5
CHEV	6
BAUDE	7

□:

RIVMAR[12:]

THE PROGRAM IS IN CONVERSATIONAL MODE: ANSWER YES OR NO TO THE QUESTIONS POSED

COPY BASIC POPULATION DATA ?
YES

BASIC POPULATION DATA

PLOT	YEAR	TREES PER SQ.M.	EGG CLUSTERS PER TREE	EGGS PER CLUSTER	HATCHED LARVAE PER CLUSTER	MATURE NYMPHS		COCOONS	
						YEAR N	YEAR N+1	PER SQUARE	PER SQUARE
4	1962	0.29010	3.35	74.560	63.94	34.65	11.32	11.84	5.38
4	1963	0.28081	1.69	67.940	64.60	39.04	14.28	12.40	9.46

PLOT	YEAR	POTENTIAL FECUNDITY	ACTUAL FECUNDITY	SEX RATIO	EGG CLUSTERS PER TREE	TREES		
						YEAR N+1	YEAR N+1	
4	1962	81.18	67.94	0.667	1.69	0.28081		
4	1963	81.18	63.26	0.679	6.25	0.27750		

IS THE PROGRAM IN USE ENTITLED LIVING?
NO

COPY NO. OF LIVING INSECTS PER SQ. M.?
YES

NO. OF LIVING INSECTS PER SQ. M.

PLOT	YEAR	AGE INTERVAL												
		0	1	2	3	4	5	6	7	8	9	10	11	12
		HATCHED EGGS	MATURE EGGS	EONYMPHS	COCOONS	COCOONS	ADULTS	FEMALES	ADJUSTMENT					
4	1962	72.46048	62.13952	33.67430	11.32148	11.84030	5.38196	0.71150	0.47457					
4	1963	32.30525	30.71709	18.56339	14.28479	12.40002	9.46148	2.55430	1.73437	1.35152				

FURTHER ANALYSES WITH THESE DATA ?
YES
NO

IS THE PROGRAM IN USE ENTITLED TABLE?
NO

COPY LIFE TABLES?
YES

LIFE TABLE

STUDY AREA : 4
YEAR : 1962

AGE	NUMBER LIVING PER SQ.	NUMBER DYING PER SQ.	PERCENT MORTALITY	SURVIVAL RATE	LOGE(10E5)X SURVIVAL RATE
0	72.4605	10.3210	14.24	0.85756	9.056681
1	62.1395	28.4652	45.81	0.54191	8.597693
2	33.6743	22.3528	66.38	0.33621	8.120307
3	11.3215	0.5188	-4.58	1.04583	9.255148
4	11.8403	6.4583	54.55	0.45455	8.421883
5	5.3820	4.6705	86.78	0.13220	7.186908
6	0.7115	0.2369	33.30	0.66700	8.805375
7	0.4746	0.0774	16.31	0.83691	9.032296
8	0.3972	72.0633	99.45	0.00548	4.003909

LIFE TABLE

STUDY AREA :⁴
YEAR : 1963

AGE	NUMBER LIVING PER METRE	NUMBER DYING PER METRE	PERCENT MORTALITY	SURVIVAL RATE	LOGE(10E5) X SURVIVAL RATE
0	32.3052	1.5882	4.92	0.95084	9.159930
1	30.7171	12.1537	39.57	0.60433	8.706713
6	18.5634	4.2786	23.05	0.76951	8.948344
8	14.2848	1.8848	13.19	0.86806	9.068844
9	12.4000	2.9385	23.70	0.76302	8.939870
10	9.4615	6.9072	73.00	0.26997	7.900891
11	2.5543	0.8199	32.10	0.67900	8.823206
12	1.7344	0.3829	22.07	0.77926	8.960925
13	1.3515	30.9537	95.82	0.04184	6.036340

IS THE PROGRAM IN USE ENTITLED SURV ?
NO

COPY LOGE(10E5(N+1)) SURVIVAL RATES ?
YES

LOGE(10E5(N+1)) SURVIVAL RATES

PLOT	YEAR	EGGS	HATCHED EGGS	MATURE LARVAE	AGE INTERVAL				ADJUSTMENT FOR FECUNDITY (GENERATION)	
					0	1	6	8		
4	1962	9.056681	8.597693	8.120307	9.255148	8.421883	7.186908	8.805375	9.032296	4.003909
4	1963	9.159930	8.706713	8.948344	9.068844	8.939870	7.900891	8.823206	8.960925	6.036340

FURTHER ANALYSES WITH THESE DATA ?
YES

IS THE PROGRAM IN USE ENTITLED VARLEYLOG ?
NO

COPY LOGE(10,000(N+1)) NO. OF INSECTS PER SQ. M.
YES

LOGE(10*5(N+1)) NO. OF LIVING INSECTS PER SQ. M.

69

PLOT	YEAR	EGGS	HATCHED	AGE INTERVAL					ADULTS	FEMALES	ADJUSTMENT FOR FECUNDITY (GENERATION)
				MATURE LARVAE	HONYMPS	COCOONS FALL	COCOONS SPRING				
4	1962	13.493383	13.339724	12.727078	11.637051	11.681858	10.893411	8.870100	8.465205	8.287202	
4	1963	12.685573	12.635163	12.131537	11.869542	11.728047	11.457579	10.148159	9.761043	9.511644	

IS THE PROGRAM IN USE ENTITLED VARLEY ?
NO

COPY 'K' FACTORS ?
YES

VARLEY AND GRADWELL K FACTORS

PLOT	YEAR	AGE INTERVAL										ADJUSTMENT FOR PECUNDITY (GENERATION)
		0	1	6	8	9	10	11	12	13	FEMALES	
		HATCHED EGGS	MATURE LARVAE	EONYMPHS	COCOONS FALL	COCOONS SPRING	ADULTS					
4	1962	0.153659	0.612646	1.090027	0.044807	0.788447	2.023311	0.404895	0.178003	5.206181		
4	1963	0.050410	0.503626	0.261995	0.141495	0.270467	1.309421	0.387116	0.249399	3.173929		

FURTHER ANALYSES WITH THESE DATA ?
YES

IS THE PROGRAM IN USE ENTITLED EGGTREND ?
NO

COPY LOGE(10*5(N+1)) EGG POPULATION TRENDS ?
YES

LOGE(10*5(N+1)) EGG POPULATION TRENDS

LOG(N+1) NO. OF
EGGS PER SQ. M.
X 10,000

PLOT	YEAR	YEAR N	YEAR N+1
	1962	13.493383	12.685573

IF FURTHER OPERATIONS WITH YOUR DATA ARE DESIRED, THEY ARE STORED :

<u>DATA</u>	<u>GLOBAL VARIABLE</u>
NO. OF LIVING INSECTS/SQ.M.	MOOSE
LOGE(10*5(N+1))	SPOCK
INSECTS/SQ.M.	GRADWELL
K FACTORS	
LOGE(10*5(N+1))	LOGSNR
SURVIVAL RATES	
LOGE(10*5(N+1))	POP
EGG POP. TRENDS	
STORAGE	VALID FOR ONE PROGRAM PASS ONLY

REFERENCES

- Gilman, L. and A.J. Rose 1970. APL/360 an interactive approach.
John Wiley & Sons, Inc., New York. 335 p.
- McLeod, J.M. 1973. Information retrieval for the Swaine jack pine
sawfly life system: a Manual of coded sampling forms.
Can. Centre Rech. For. Laurentides, Ste-Foy, Que.
Rapp. Inf. LAU-X-2. 95 p.
- Southwood, T.R.E. 1966. Ecological methods with particular reference
to the study of insect populations. Methuen and Co. Ltd.,
London. 391 p.