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AN INTERACTIVE PROGRAM FOR THE
DOUGLAS-FIR TUSOCK MOTH
STAND OUTBREAK MODEL

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AN INTERACTIVE PROGRAM FOR THE DOUGLAS-FIR TUSSOCK MOTH
STAND OUTBREAK MODEL [] .

1939-
100 John Wong¹ and Bruce Danielson²

ABSTRACT

An interactive program has been installed at the Fort Collins Computer Center (FCCC) to assist users to create data files required for the Douglas-fir Tussock Moth Stand Outbreak Model programs. Instructions on how to use this interactive program are provided via examples in this report.

INTRODUCTION

Through a cooperative effort between Pacific Northwest Forest and Range Experiment Station and FPM/Methods Application Group, a report entitled "Data Preparation and Computer Runstream Procedures for the Douglas-fir Tussock Moth Stand Outbreak Model" was distributed (Colbert and Wong 1979). It was prepared under the premise that a comprehensive reference document should be assembled to serve as a single source of information on data input and output structure and computer access procedures for this model. The stand outbreak model is a component of the Douglas-fir Tussock Moth (DFTM) Pest Management System (Campbell and McFadden) developed under the USDA Expanded DFTM Research and Development Program (Wright 1977). This model has a generalized system structure. When new information becomes available it can be readily updated.

The basic documentation on the DFTM Stand Outbreak Model described data input and output structure for a variety of available options. However, the need exists to further simplify the data preparation procedures so that users with a minimal amount of training can readily create data files required to make simulations. To satisfy this need, an interactive program has been developed and placed on line at FCCC. Designed strictly for demand processing, this program can be accessed by an authorized FCCC user from a remote terminal.

In this report, it is assumed that the reader has already reviewed the aforementioned documentation for the DFTM Stand Outbreak Model (Colbert and Wong 1979). The reader should therefore be knowledgeable about the input

-
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files required and the information needed to make up these files. Primary intent of this report is to demonstrate how this new program can be utilized.

SYSTEMS OVERVIEW

The interactive program is conversational in nature and is capable of performing the following tasks:

1. Create the initial condition file (*IC.) and the parameters file (*PARAMETERS.) simultaneously (option 1) as input files for a simulation.
2. Create the specifications file (*SPECTAB4.) to retrieve detail information from a previous simulation (option 2).
3. Compute instar specific daily larval, pupal or overwintering mortality resulting from direct control as input to the generation of the parameters file (option 3).

This program is written in ASCII Fortran for the UNIVAC 1100 computer at FCCC. It resides in a program file named DFTM*UTILITY1.

PROGRAM FEATURES

Several special features have been built into the interactive program which will transform field data into a form readily acceptable by the model programs. Some of these special features are:

1. Capability to Enter Model at Any Stage of the Outbreak.

The DFTM Stand Outbreak Model was structured in a form such that the insect density (larval count) and the actual foliage conditions must be specified at the initiation (1st instar) of a phase. This requirement is not practical from the standpoint that insect densities at the 1st instar are not always available except under an established monitoring system when field activities are planned in advance. Recognizing this situation, the capability to "back-up" insect count available at some intermediate point, e.g. at the third day of the second instar, to the beginning of the first instar, has been incorporated into this program. To accomplish this task, the following functional form for insect survivorship is utilized:

$$N = N_0 \prod_{i=1}^k \prod_{j=1}^l (1 - p_{ij})^{d_{ij}}$$

where N = insect density at the initiation of a specific phase.

N_0 = instar density at the time of data collection.

i = the type of mortality associated with instar i .

P_{ij} = the mortality (value) associated with i and j .

d_{ij} = the time in days to be included for each instar.

2. Ability to Adjust Mortality Factors and Foliage Biomass Values.

A set of natural mortalities are stored within the program in the *PARAMETERS. file. Users can utilize these standard mortalities or make alterations when executing this program if other values are to be used. Foliage conditions--actual new foliage biomass and actual old foliage biomass in addition to nominal percent new foliage and nominal total foliage biomass--at the first instar of a specific phase must be available for a simulation to start from other than phase 1. For the phase 1 start, the actual foliage complements will be automatically computed from the nominal foliage values supplied by the user.

3. Ability to Create an Input File to Retrieve Detailed Information.

Option 2 provides the mechanism to set up the SPECTAB4. file to retrieve model details for up to six state or output variables; namely, new foliage biomass, old foliage biomass, number of insects, mean larval biomass, number of days on old foliage, and number of days without food. By entering the appropriate pair of indices sequentially, as shown in Fig. 8 of the basic considerations, the desired output can be obtained by executing DFTM*RUNSTREAM.TABLE4B.

4. Control Mortality Computation.

Another special feature is found in option 3, which is the control mortality algorithm. With this option, the user can obtain a value for the required control mortality factor to be entered into *PARAMETERS, when option 1 is processed. Using the same functional form as in the above formula, the daily control mortality or overwintering and pupal control mortality, as applicable, can be easily calculated. For the daily control rate, it is assumed that the initial and final insect densities are known at the beginning and end of instar. It is then computed as a function of these values, and all other mortalities entered. Furthermore, if stress mortality is to be considered, in computing daily control mortality, the user is expected to supply the number of days for which stress will operate³. In order to obtain an estimate of the number of days for which stress will operate a preliminary simulation will have to be made

3 Number of days stress operates is the number of days on old foliage.

with a phase 1 start, with insect densities ranging from 1-20 larvae/1000 square inch of foliage, and with nominal foliage conditions that best approximate the situations at hand. After this simulation is made, the information on the number of days on old foliage can be retrieved as discussed above.

EXAMPLES

The following synopsis was developed to show an example of how the Douglas-fir Tussock Moth Stand Outbreak Model with its new interactive front-end program could be used to make a pest management decision.

A combination of pheromone trapping and larval sampling indicates that a major up-surge of Douglas-fir tussock moth is about to occur in portions of eastern Oregon during late 1983. The infested area encompasses approximately 150,000 acres of predominately grand fir type. The outbreak is assumed to be entering Phase II in 1984. In October 1983, a decision must be made whether or not to begin plans for a direct control project.

Data from biological evaluations identifies five areas of infestation. Projected average 1st instar population trends in these areas at the beginning of Phase II are as follows:

<u>Infestation Area</u>	<u>Projected 1st Instar Larvae</u> (insects per 1,000 sq. in. of foliage)
1	50
2	75
3	110
4	150
5	200

At the time of this initial evaluation, no data are available on incidence of naturally occurring virus in the population of egg parasite levels or proportion of nonviable eggs. According to existing data, the proportion of nominal new foliage for grand fir in eastern Oregon is 30 percent and nominal foliage biomass on a mid-crown branch is 230 grams/1000 sq. in. The actual amount of new and old foliage at the beginning of Phase II is estimated to be 69 grams and 161 grams, respectively.

One alternative under consideration is direct control of the infestation with an aerial application of Sevin 4-Oil at 2 lbs to 3/4 gal. carrier per acre. Data from a 1974 pilot control project in northern Idaho (Ciesla et al. 1976) is used to compute daily mortality rates; and the Stand Outbreak Model is run with or without introduction on direct control to project population trends and impact. Data from this pilot control project were collected under the following conditions:

1. Phase of outbreak is Phase III.
2. Instar to which spray was applied was primarily the 3rd instar.
3. Prespray population density was 50.71 insects per 1,000 sq. in. of foliage.
4. Seven-day post-spray population density = 5.58 insects per 1,000 in. of foliage.
5. Fourteen day post-spray population density = .96 insects per 1,000 in. of foliage.

To use the Stand Outbreak Model for pest management decisionmaking, compute a daily control mortality rate from the 1974 data; enter that rate into the parameter file; and run simulations with and without a direct control mortality factor with a Phase II start; and then compare the population trends and impact.

The first step is to create *IC. and *PARAMETERS. files for the no control option as follows:

Runstream No. 1

Using these input files, make a simulation without control as follows:

```
>@RUN M01MAG,11052034050 ,WONG
DATE: 080680 TIME: 114337
S2K INFO - , S2000,80=00006 (@INFO)MONDAY 11:35
<@XQT DFTM*UTILITY1.
```

```
DFTM OUTBREAK MODEL DATA PREPARATION UTILITY
VERSION 01.001 COMPILED 6/3/80
```

```
PROGRAM OPTIONS: 1= IC AND PARAMETERS FILE GENERATION
                  2= SPECTAB4 FILE GENERATION,
                  3= CONTROL MORTALITY ALGORITHM
```

ENTER OPTION DESIRED

>1

*IC. FILE AND *PARAMETER. FILE GENERATION

ENTER RUN QUALIFIER

>WC1

RUN QUALIFIER IS NOW WC1

ENTER NUMBER OF DOUGLAS FIR TREE CLASSES

>0

ENTER NUMBER OF GRAND FIR TREE CLASSES

>5

ENTER STARTING PHASE NUMBER

>2

DO YOU WANT TO DEFINE SUBSETS? (YES/NO)

>NO

DO YOU WISH TO CHANGE PARAMETERS FILE VALUES?(YES/NO)

>NO

INITIAL CONDITIONS FILE GENERATION

ENTER NUMBER OF DAYS STRESS OPERATES IN

FIRST INSTAR, SECOND INSTAR, THIRD INSTAR, FOURTH INSTAR

>0,0,0,0

TREE CLASS DEFINITIONS:

YOU HAVE SPECIFIED 000 DOUGLAS FIR TREE CLASSES

AND 005 GRAND FIR TREE CLASSES. FOR EACH CLASS

YOU WILL NEED TO ENTER 1 LINE CONTAINING THE FOLLOWING VALUES:

1. NOMINAL % NEW FOLIAGE
2. NOMINAL TOTAL FOLIAGE BIOMASS
3. # OF VIABLE EGGS PER BRANCH
4. INSTAR OF EGG COUNT
5. DAY IN INSTAR OF EGG COUNT

```

        6. ACTUAL NEW FOLIAGE BIOMASS
        7. ACTUAL OLD FOLIAGE BIOMASS
>30,230,50,1,1,69,160
>30,230,75,1,1,69,161
>30,230,110,1,1,69,160
>30,230,150,1,1,69,161
>30,230,200,1,1,69,161
IF YOU WANT A LISTING OF THE ENTIRE *IC FILE, ENTER      -1,-1,0
IF YOU WANT TO SEE ONE LINE, ENTER LINE#,0,0
IF YOU WANT TO CHANGE A VALUE, ENTER LINE#,ITEM#,NEW VALUE
TO CONTINUE WITH PROGRAM, ENTER 0,0,0
>1,7,161
LINE 1 ITEM 7= 161.000
>3,7,161
LINE 3 ITEM 7= 161.000
>-1,-1,0
 2 .000000 .000000 30.000000230.000000 69.000000161.000000 50.000000 1
 2 .000000 .000000 30.000000230.000000 69.000000161.000000 75.000000 2
 2 .000000 .000000 30.000000230.000000 69.000000161.000000110.000000 3
 2 .000000 .000000 30.000000230.000000 69.000000161.000000150.000000 4
 2 .000000 .000000 30.000000230.000000 69.000000161.000000200.000000 5
>0,0,0
*IC. AND *PARAMETERS. FILE PREPARATION FOR PHASE 2 START COMPLETED
****GOODBYE****
>@FIN 4

```

4 Cost for this run was \$1.34.

Using these input files, make a simulation without control as follows:

Runstream No. 2

```
>@RUN M01MAG, 1105203405 , WONG
DATE: 080680 TIME: 115321
S2K INFO - , S2000,80-00006 (@INFO)MONDAY 11:35
>@QUAL WC1
READY
>@ADD,L DFTM*RUNSTREAM.PRE2
```

```
@DELETE,C *LUN25.
FURPUR 27R3A E35 SL73R1 08/06/80 11:54:34
```

```
*LUN25 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000
```

```
@ASG,UP *LUN25.
READY
```

```
*USE 25,*LUN25
READY
```

```
@DELETE,C *LUN10.
FURPUR 27R3A E35 SL73R1 08/06/80 11:54:44
```

```
*LUN10 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000
```

```
@ASG,UP *LUN10.
READY
```

```
@USE 10,*LUN10
READY
```

```
@ASG,T *4
READY
```

```
@ASG,T *5
READY
```

```
@ASG,T *6
READY
```

@ASG,T *7
READY

@ASG,T *8
READY

@ASG,T *9
READY

@ASG,T *11
READY

@ASG,T *12
READY

@DELETE,C *15.
FURPUR 27R3A E35 SL73R1 08/06/80 11:55:34

*15 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000

@ASG,UP *15
READY

@FREE *15.
READY

@ASG,A *15.
READY

@DELETE,C *16.
FURPUR 27R3A E35 SL73R1 08/06/80 11:56:06

*16 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000

@ASG,UP *16
READY

@FREE *16.
READY

*ASG,A *16.
READY

*DELETE,C *17
FURPUR 27R3A E35 SL73R1 08/06/80 11:56:28

*17 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000

@ASG,UP *17
READY

@FREE *17.
READY

@ASG,A *17.
READY

@ASG,T *18
READY

@ASG,T *19
READY

@ASG,T *20
READY

@DELETE,C *21.
FURPUR 27R3A E35 SL73R1 08/06/80 11:56:52

*21 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400100000000

@ASG,UP *21
READY

@FREE *21.
READY

@ASG,A *21.
READY

@ASG,T *22
READY

@ASG,T *23
READY

@ASG,T *24
READY

@ASG,A DFTM*DFTMDF.
FACILITY WARNING 000200000000

@USE 13,DFTM*DFTMDF
READY

@ASG,A DFTM*DFTMGF.
FACILITY WARNING 000200000000

@USE 14,DFTM*DFTMGF
READY

@ASG,A *IC.
READY

@ASG,A *PARAMETERS.
READY

@USE 30,*IC
READY

@USE 60,*PARAMETERS
READY
>@XQT DFTM*OUTBREAK.
>@ADD,L DFTM*RUNSTREAM.POST2

@FREE *2
FACILITY WARNING 100000000000

@FREE *3
FACILITY WARNING 100000000000

@FREE *4
READY

@FREE *5
READY

@FREE *6
READY

@FREE *7
READY

@FREE *8
READY

@FREE *9
READY

@FREE *10
READY

@FREE *11
READY

@FREE *12
READY

@FREE *13
READY

@FREE *14
READY

@FREE *18
READY

@FREE *19
READY

@FREE *20
READY

@FREE *21
READY

@FREE *22
READY

@FREE *23
READY

@FREE *24
READY

@FREE *25
READY
>@SYM,U *15.,,FCR104
>@SYM,U *16.,,FCR104
>@SYM,U *17.,,FCR104
>@FIN⁵

5 Cost for this run was \$3.37.

Then compute a direct control daily mortality rate. The runstream appears as follows:

Runstream No. 3

```

UNS>@RUN M01MAG,1105203405 WONG
DATE: 080680 TIME: 113813
S2K INFO -, S2000,80-00006 (@INFO)MONDAY 11:35
>@XQT DFTM*UTILITY1.

DFTM OUTBREAK MODEL DATA PREPARATION UTILITY
  VERSION 01.001  COMPILED 6/3/80

PROGRAM OPTIONS:  1= IC AND PARAMETERS FILE GENERATION
                  2= SPECTAB4 FILE GENERATION,
                  3= CONTROL MORTALITY  ALGORITHM
ENTER OPTION DESIRED
>3
CONTROL MORTALITY ALGORITHM

ENTER OPTION CODE
  DAY=DAILY CONTROL MORTALITY
  PUP=PUPAL CONTROL MORTALITY
  OVW=OVERWINTER CONTROL MORTALITY
  TER=TERMINATE PROGRAM
>DAY
ENTER PHASE
>3
ENTER INSTAR
>3
ENTER TREE TYPE (DF=DOUGLAS FIR,GF=GRAND FIR)
>GF
NATURAL DAILY MORTALITIES:
PREDATOR/PARASITE= .003 DISEASE= .006 BACK GROUND= .020 STRESS= .100
CHANGE ANY NATURAL MORTALITIES?(YES/NO)
>NO
ENTER NUMBER OF DAYS STRESS OPERATES
>0
ENTER BEGINNING INSECT COUNT
>50.71
ENDING INSECT COUNT WITH NATURAL MORTALITY ONLY= 37.9
ENTER ENDING COUNT WITH CONTROL
>3.06
DAILY CONTROL MORTALITY= .2239
ENTER OPTION
>TER
ROUTINE TERMINATED
CONTROL MORTALITY ALGORITHM COMPLETED
****GOODBYE****
>@FIN

```

6 This number was estimated from 1974 pilot project data.

7 Cost for this run was \$0.37.

Next create the *IC. and *PARAMETERS. File for the direct control option as follows:

Runstream No. 4

```
>@RUN M01MAG,1105203405 ,WONG
DUP ID, NEW ID IS M01MAH
DATE: 080680 TIME: 120321
S2K INFO - , S2000,80-00006 (@INFO)MONDAY 11:35
>@XQT DFTM*UTILITY1.
```

DFTM OUTBREAK MODEL DATA PREPARATION UTILITY
VERSION 01.001 COMPILED 6/3/80

PROGRAM OPTIONS: 1= IC AND PARAMETERS FILE GENERATION
2= SPECTAB4 FILE GENERATION,
3= CONTROL MORTALITY ALGORITHM

ENTER OPTION DESIRED

```
>1
*IC. FILE AND *PARAMETER. FILE GENERATION
```

ENTER RUN QUALIFIER

```
>WC2
```

RUN QUALIFIER IS NOT WC2

ENTER NUMBER OF DOUGLAS FIR TRE CLASSES

```
>0
```

ENTER NUMBER OF GRAND FIR TREE CLASSES

```
>5
```

ENTER STARTING PHASE NUMBER

```
>2
```

DO YOUT WANT TO DEFINE SUBSETS? (YES/NO)

```
>NO
```

WHAT?

```
>NO
```

DO YOU WISH TO CHANGE PARAMETERS FILE VALUES?(YES/NO)

```
>YES
```

TO CHANGE A PARAMETERS FILE VALUE,ENTER A TRIPLE
(RECORD NUMBER,ITEM NUMBER,NEW VALUE)

TO OBTAIN THE LABEL AND CURRENT VALUE OF A PARTICULAR ITEM,ENTER
A TRIPLE (-RECORD NUMBER,ITEM NUMBER,0)

TO PRINT THE ENTIRE PARAMETERS FILE ENTER THE TRIPLE -1,-1,0

WHEN YOU ARE DONE ENTERING VALUES, ENTER THE TRIPLE 0,0,0
 >14,1,2239
 RECORD 14, ITEM 1
 DAILY CONTROL MORTALITY RATE⁸ FOR PHASE 2 INSTAR 1
 HAS THE VALUE .2239000
 >0,0,0

INITIAL CONDITIONS FILE GENERATION
 ENTER NUMBER OF DAYS STRESS OPERATES IN
 FIRST INSTAR, SECOND INSTAR, THIRD INSTAR, FOURTH INSTAR
 >0,0,0,0

TREE CLASS DEFINITIONS:

YOU HAVE SPECIFIED 000 DOUGLAS FIR TREE CLASSES
 AND 005 GRAND FIR TREE CLASSES. FOR EACH CLASS
 YOU WILL NEED TO ENTER 1 LINE CONTAINING THE FOLLOWING VALUES:

1. NOMINAL % NEW FOLIAGE
2. NOMINAL TOTAL FOLIAGE BIOMASS
3. # OF VIABLE EGGS PER BRANCH
4. INSTAR OF EGG COUNT
5. DAY IN INSTAR OF EGG COUNT
6. ACTUAL NEW FOLIAGE BIOMASS
7. ACTUAL OLD FOLIAGE BIOMASS

>30,230,50,1,1,69,161

>30,230,75,1,1,69,161

>30,230,110,1,1,69,161

>30,230,150,1,1,69,161

>30,230,200,1,1,69,161

IF YOU WANT A LISTING OF THE ENTIRE *IC FILE, ENTER -1,-1,0

IF YOU WANT TO SEE ONE LINE, ENTER LINE #,0,0

IF YOU WANT TO CHANGE A VALUE, ENTER LINE #, ITEM#, NEW VALUE

TO CONTINUE WITH PROGRAM, ENTER 0,0,0

>-1,-1,0

2	.000000	.000000	30.000000	230.000000	69.000000	161.000000	50.000000	1
2	.000000	.000000	30.000000	230.000000	69.000000	161.000000	75.000000	2
2	.000000	.000000	30.000000	230.000000	69.000000	161.000000	110.000000	3
2	.000000	.000000	30.000000	230.000000	69.000000	161.000000	150.000000	4
2	.000000	.000000	30.000000	230.000000	69.000000	161.000000	200.000000	5

>0.0.0

*IC. AND *PARAMETER. FILE PREPARATION FOR PHASE 2 START COMPLETED

****GOODBYE****

>@FIN 9

8 Direct control applied at Phase II, Instar 1.

9 Cost for this run was \$1.30.

Finally, run a simulation with the control option as follows:

Runstream No. 5

```
>@RUN M01MAG,1105203405 , CIESLA
DUP ID, NEW ID IS M01MAH
DATE: 180680 TIME: 121251
S2K INFO - , S2000,80-00006 (@INFO)MONDAY 11:35
>@QUAL WC2
READY
>@ADD,L DFTM*RUNSTREAM.PRE2
```

```
@DELETE,C *LUN25.
FURPUR 27R3A E35 SL73R1 08/06/80 12:14:04

LUN25 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000
```

```
@ASG,UP *LUN 25.
READY
```

```
@USE 25,*LUN25
READY
```

```
@DELETE,C *LUN10.
FURPUR 27R3A E35 SL73R1 08/06/80 12:14:17

@LUN10 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000
```

```
@ASG,UP *LUN10.
READY
```

```
@USE 10,LUN10
READY
```

```
@ASG,T *4
READY
```

```
@ASG,T *5
READY
```

@ASG,T *6
READY

@ASG,T *7
READY

@ASG,T *8
READY

@ASG,T *9
READY

@ASG,T *11
READY

@ASG,T *12
READY

@DELETE,C *15.
FURPUR 27R3A E35 SL73R1 08/06/80 12:14:48

*15 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000

@ASG,UP *15
READY

@FREE *15.
READY

@ASG,A *15.
READY

@DELETE,C *16.
FURPUR 27R3A E35 SL73R1 08/06/80 12:15:15

*16 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000

@ASG,UP *16
READY

@FREE *16.
READY

@ASG,A *16.
READY

@DELETE,C *17.
FURPUR 27R3A E35 SL73R1 08/06/80 12:15:37

* 17 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000

@ASG,UP *17
READY

@FREE *17.
READY

@ASG,A *17.
READY

@ASG,T *18
READY

@ASG,T *19
READY

@ASG,T *20
READY

@DELETE,C *21.
FURPUR 27R3A E35 SL73R1 08/06/80 12:15:58

*21 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000

@ASG,UP *21
READY

@FREE *21.
READY

@ASG,A *21.
READY

@ASG,T *22
READY

@ASG,T *23
READY

@ASG,T *24
READY

@ASG,A DFTM*DFTMDF.
FACILITY WARNING 000200000000

@USE 13,DFTM*DFTMDF
READY

@ASG,A DFTM*DFTMGF.
FACILITY WARNING 000200000000

@USE 14,DFTM*DFTMGF
READY

@ASG,A *IC.
READY

@ASG,A *PARAMETERS
READY

@USE 30,*IC
READY

@USE 60,*PARAMETERS
READY
>@XQT DFTM*OUTBREAK.
>ADD,L DFTM*RUNSTREAM.POST 2
ADDX
DATA IGNORED - IN CONTROL MODE
>AD
@ADD,L DFTM*RUNSTREAM.POST2

@FREE *2
FACILITY WARNING 10000000000000

@FREE *3
FACILITY WARNING 10000000000000

@FREE *4
READY

@FREE *5
READY

@FREE *6
READY

@FREE *7
READY

@FREE *8
READY

@FREE *9
READY

@FREE *10
READY

@FREE *11
READY

@FREE *12
READY

@FREE *13
READY

@FREE *14
READY

@FREE *18
READY

@FREE *19
READY

@FREE *20
READY

@FREE *21
READY

@FREE *22
READY

@FREE *23
READY

@FREE *24
READY

@FREE *25
READY

>@SYM,U *15.,,FCR104
>@SYM,U *16.,,FCR104
>@SYM,U *17.,,FCR104
>FIN 10

10 Cost for this run was \$3.46.

Model outputs for control vs no control under these conditions are compared in tables 1-6 for each infested area. After these model simulations have been made, option 2 of the front-end program was used to create the specification file to make a post-simulation run. The runstream for creating the specification file follows:

Runstream No. 6

```
>@RUN M01MAG,1105203405 ,WONG
DATE: 08/11/80 TIME: 115751
>@ASG,A DFTM*UTILITY1.
READY
>@XQT DFTM*UTILITY1.
```

```
DFTM OUTBREAK MODEL DATA PREPARATION UTILITY
VERSION 01.001 COMPILED 6/3/80
```

```
PROGRAM OPTIONS: 1= IC AND PARAMETERS FILE GENERATION
                  2= SPECTAB4 FILE GENERATION.
                  3= CONTROL MORTALITY ALGORITHM
```

ENTER OPTION DESIRED

>2

*SPECTAB4. FILE GENERATION

ENTER RUN QUALIFIER

>WC2

RUN QUALIFIER IS NOW WC2

ENTER NUMBER OF TREE CLASSES

>5

ENTER PAIRS OF NUMBERS(ONE PAIR PER LINE) FOR EACH ITEM DESIRED FROM THE TABLE4. PROGRAM.

WHEN FINISHED ENTERING PAIRS,ENTER 0,0

>1,3

>2.3

>3.3

>4.3

>5.3

>6.3

>7.3

>8.3

>9.3

>10.3

>0,0

OPTION CODES:

T=TERMINATE PROGRAM NORMALLY

C=CHANGE AN ITEM IN *SPECTAB4. FILE

A=ADD AN ITEM TO *SPECTAB4. FILE

L=LIST CURRENT *SPECTAB4. FILE

D=DELETE AN ITEM FROM *SPECTAB4. FILE

ENTER OPTION CODE

>T

WC2*SPECTAB4 HAS BEEN GENERATED WITH 10 ITEMS

*SPECTAB4. FILE PREPARATION COMPLETED

****GOODBYE****

>@FIN¹¹

11 Cost for the run was \$0.87.

With this specification file, a computer run was made to retrieve information on the numerical changes of the population resulting from control. The runstream for the post-simulation run follows:

Runstream No. 7

```
>@RUN M01MAG,1105203405 ,WONG
DATE: 081180 TIME: 120252
>@QUAL WC2
READY
>@ADD,L DFTM*RUNSTREAM,TABLE4B
```

```
@ASG,A *SPECTAB4
READY
```

```
@ASG,A *LUN10.
READY
```

```
@ASG,A *LUN25.
READY
```

```
@DELETE,C *TABLE4.
FURPUR 27R3A E35 SL73R1 08/11/80 12:03:38
```

```
*TABLE4 IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 400010000000
```

```
@ASG,CP *TABLE4.
READY
```

```
@USE 11,*TABLE4
READY
```

```
@USE 12,*SPECTAB4
READY
```

```
@USE 10,*LUN10
READY
```

```
@USE 25,*LUN25
READY
```

@XQT DFTM*NTABLE4.A2
THERE WERE 5 TREE CLASSES COUNTED IN *LUN10.
REQUEST IS TO PROCESS THE FIRST 5 TREE CLASSES
THERE WERE 10 VALID ITEMS REQUESTED

@FREE 11
READY

@FREE *TABLE4.
FACILITY WARNING 10000000000000

@FREE 12
READY

@FREE 10
READY

@FREE 25
READY
>@SYM,U *TABLE4.,2,FCR104
>@FIN 12

12 Cost of this run was \$0.53.

The output table from this run is shown in Table 7.

The user should find it very instructional to construct examples similar to those provided in this report. With a few practice sessions on the terminal, the operating characteristics of the front-end program can be grasped quickly, by a person with very little background in computers. When a large number of simulations have to be made, this program should prove to be a real time saving tool.

PROGRAM VARIABLE DEFINITIONS

In this Section, the definitions of the variables names used in the program source codes are explained in terms of their name, type, size, and usage. The source codes for this program can be made available upon request. It is anticipated that additional capabilities will be installed as the need arises. Revisions of this document will be made accordingly to provide the user with the latest information.

ICFILE (Subroutine):

<u>NAME</u>	<u>TYPE</u>	<u>SIZE</u>	<u>USAGE</u>
ITIC	I	200,9	matrix containing the integer values of the IC file
TIC	R	200,9	matrix containing the real values of the IC file
NOTE: ITIC and TIC have been equivalenced and are therefore actually stored in the same memory locations. Use of ITIC and TIC allow both real and integer values to be stored in the same matrix			
NDF	I		user-input number of Douglas-fir tree classes
NGF	I		user-input number of Grand fir tree classes
NTC	I		total number of tree classes (NDF + NGF)
NPHASE	I		user-input starting phase
IND	I		counter for number of tree classes processed so far. In this version also use as the tree class index (9th item in the current record of the IC file) & equal to K
TIC(K,8)	R		calculated insect density for Kth tree class. If TIC(K,8) is greater than 1000, message printed and program terminated

<u>NAME</u>	<u>TYPE</u>	<u>SIZE</u>	<u>USAGE</u>
ITIC(K,1)	I		species code (1 = Douglas-fir; 2 = Grand fir)
I1	I		user-input editing code for IC file. May be a line (or row, or record) number of an entry in the IC file or merely a code for printing or continuation of program
I2	I		user-input editing code for IC file. May be an item (or column) number of an entry in the IC file or merely a code for printing or continuation of program
VAL	R		user-input new value for the (I1,I2)th entry in the IC file or a code for printing or continuation of program
IVAL	I		integer form of VALUE for integer entries in the IC file
SDAY	I	6	Number of days stress operates in instars 1 to 6. SDAY (1) to SDAY (4) are user input; SDAY (5) and SDAY (6) are always zero.
K	I		Line (or record) number of current tree class in IC file

PRFILE (Subroutine):

NTC	I		number of tree classes
NPHASE	I		starting phase
PRN	R	24.6	matrix containing records 2-25 of the PARAMETERS file
IPR1	I	22	vector containing first record of the PARAMETERS file
ANSW	C*3		character variable containing a user-input response (yes/no)
ICODE	I		numerical code corresponding to value of ANSW: "no" = -1, "yes" = +1, otherwise = 0
I	I		user-input number of tree class subsets before checking for allowable values
NPOSUB	I		maximum possible number of subsets given the number of tree classes (NTC)

<u>NAME</u>	<u>TYPE</u>	<u>SIZE</u>	<u>USAGE</u>
NSUBS	I		number of tree class subsets after checking for allowable values
I1	I		current user-input low subset index before checking for error. Becomes IPR1(J2 + 1) if no error
I2	I		current user-input high subset index before checking for error. Becomes IPR1(J2 + 2) if no error
VALUE	R		user-input new value for (I1, I2)th entry in the PARAMETERS file
J	I		subset currently being input is the Jth subset
J2	I		position of last accepted entry in IPR1 vector (=J*2 because entries 1 and 2 in IPR1 are always NPHASE & NTC, and because there are 2 entries per subset pair)

MAIN (Main Program):

IPR1	I	22	vector containing the first record of the PARAMETERS file
PRN	R	24,6	matrix containing records 2-25 of the PARAMETERS file
IOPT	I		option code for desired subroutine

AMPLF (Subroutine):

I	I		record (or row) number of item in PARAMETERS file
J	I		item (or column) number of item in PARAMETERS file
IPR1	I	22	vector containing first record of the PARAMETERS file
PRN	I	24,6	matrix containing records 2-25 of the PARAMETERS file
M	I		M = ABS(I)
N	I		N = ABS(J)
IR	I		IR = N module 2 (used in the program to determine whether an item number is odd or even)

<u>NAME</u>	<u>TYPE</u>	<u>SIZE</u>	<u>USAGE</u>
INDEX	I		number of tree class subset cooresponding to item (1,j) in the PARAMETERS file
<u>SALUTE</u> (Subroutine):			
IGEN	I		generation number (changed when recompiling program)
IVER	I		version number (changed when recompiling program)
CDATE	I	8	date of compilation (changed when recompiling)
<u>SOLONG</u> (Subroutine):			
IOPT	I		subroutine option code
NPHASE	I		starting phase
<u>NCLASS</u> (Subroutine):			
NCL	I		number of tree classes (input by user)
IL	I		lower bound to number of tree classes (fixed in program version)
IH	I		upper bound to number of tree classes (fixed in program version)
<u>ABRTR</u> (Subroutine):			
ISTAT	I		error status code returned after executive request initiated by routine FACSF
<u>GETFLS</u> (Subroutine):			
CCD	C*40		contains character string for the @QUAL executive request
QUAL	C*72		user-entered run qualifier including leading and trailing blanks
QUALIF	C*1	12	qualifier squeezed down to 12 characters (including trailing blanks, if any)

<u>NAME</u>	<u>TYPE</u>	<u>SIZE</u>	<u>USAGE</u>
QTEST	C*1		contains sequential characters from QUAL for testing (for blanks). Also used as user-input response code.
IDUPMS	0		octal error status code for: "another file already assigned with same number but different qualifer"
INOCAT	0		octal error status code for: "no cataloged file with name given in an @DELETE executive request"
ISTAT	I		error status returned after executive request initiated by FACSf routine
LQUAL	I		counter for number of characters in qualifier
ISTATR	I		same usage as ISTAT
QTEST	I		also used to contain a character-type user response
I	I		counter for number of characters in QUAL checked for blanks

TCLASS (Subroutine):

NEND	I		counter for number of EOF's read - if greater than 2, run is terminated
NF	I		number of tree classes
TYPE	R		variable indicates record number of appropriate stress mortality (DF or GF) in PRN matrix-- = 18 for DF, = 19 for GF
IPR1	I	22	vector containing first record of PARAMETERS file
PRN	R	24,6	matrix containing records 2 through 25 of PARAMETERS file
NDFC	I		number of Douglas-fir tree classes
FIC	R	200,9	matrix containing entries for the IC file
INSTAR	I		instar of insect count
DAY	I		day within instar of insect count
FIC6	R		if NPHASE is greater than 1, 6th item in current record of FIC (actual new foliage biomass) is set = FIC6

<u>NAME</u>	<u>TYPE</u>	<u>SIZE</u>	<u>USAGE</u>
FIC7	R		if NPHASE is greater than 1, 7th item in current record of FIC (actual old foliage biomass) is set = FIC7
I	I		counter for number of times user has input a line of data
NPHASE	I		starting phase
D	R		total survivorship from beginning of phase to INSTAR, DAY
IENT	I		number of records read so far
ILEFT	I		number of records left to be read
NDAY	I	6	same usage as SDAY in ICFIL routine
INITID	L		not used in this version

CHANGE (Subroutine):

I	I		indicates record (or row) number of entry in PARAMETERS file
J	I		indicates item (or column) number of entry in PARAMETERS file
VAL	R		new value for (I,J)th entry in PARAMETERS file
IVAL	I		new value for (1,j)th entry in PARAMETERS file
IPR1	I	22	vector containing first record of PARAMETERS file
PRN	R	24,6	matrix containing records 2-25 of PARAMETERS file

SPCT4 (Subroutine):

IX1	I		user-input first member of pair before checking for error
IX2	I		user-input second member of pair before checking for error
I	I		counter for number of characters checked for blank in QUAL. Also counter for number of pairs entered in I1 & I2 vectors
KTOTAL	I		number of tree classes

NITEM	I		number of accepted items (pairs) in SPECTAB4
NUM	I		position number of pair for editing
ICK	I		loop index for checking new pair for duplication in existing pair list
CCD	C*40		contains the character string that makes up executive request "@QUAL (qualifier)"
QUAL	C*72		user-entered run qualifier including leading and trailing blanks
QTEST	C*1		contains successive single characters from QUAL for testing (for blank character). Also used as user-input response code.
QUALIF	C*1	12	qualifier squeezed down to 12 characters (including trailing blanks, if any)
I1	I	47	vector of 1st members of SPECTAB4 pairs
I2	I	47	vector of 2nd members of SPECTAB4 pairs
IDUPMS	0		octal error status code for: another file exists with same name but a different qualifier (usually following an @ASG executive request)
INOCAT	0		octal error status code for: no existing cataloged file with name given in an @DELETE executive request
ISTAT	I		error status returned after executive request command initiated through FACSf routine
LQUAL	I		counter for number of characters in qualifier

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Table 2. Second output table from simulation without control.

TREE CLASS NO.	NUMBER OF TREES	WEIGHT FACTOR PER TREE	INITIAL VIABLE EGGS	MODEL BRANCH: PERCENT DEFOLIATION BY PHASE				PERCENT OF TREE		PER CENT OF TREES RECEIVING:			
				I	II	III	IV	TOTALLY DEFOLIATED	DIRECT MORTALITY	SECONDARY MORTALITY	TOP KILL	ONLY GROWTH REDUCTION	
1	.0	.0	.000	.000	26.133	66.900	48.672	12.035	.0	4.4	5.6	90.0	
2	.0	.0	.000	.000	43.814	87.851	72.605	92.358	17.3	9.3	34.4	39.0	
3	.0	.0	.000	.000	67.792	73.004	54.086	35.016	.9	4.5	27.0	67.6	
4	.0	.0	.000	.000	88.232	89.713	73.182	94.279	17.3	9.3	34.4	39.0	
5	.0	.0	.000	.000	95.358	96.636	81.143	97.343	47.7	7.8	21.5	23.0	

TREE CLASS NO.	NUMBER OF TREES	WEIGHT FACTOR PER TREE	INITIAL VIABLE EGGS	PER CENT OF TREES BY PERCENT REDUCTION IN CROWN HEIGHT				GROWTH IN SURVIVING TREES WITH NO TOP KILL		DIAMETER GROWTH IN TREES WITH TOP KILL		
				0.0	5.0	17.5	37.5	70.0	DIAMETER PERCENT OF NOMINAL	HEIGHT	PERCENT OF NOMINAL	
1	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00	
2	.0	.0	.00	19.3	5.9	2.2	1.6	5.4	69.10	69.10	69.10	
3	.0	.0	.00	13.3	8.9	3.2	1.2	.4	74.00	74.00	74.00	
4	.0	.0	.00	19.3	5.9	2.2	1.6	5.4	69.10	69.10	69.10	
5	.0	.0	.00	9.6	4.0	2.7	.0	5.1	61.90	61.90	61.90	

Table 3. Third output table from simulation without control.

DESCRIPTION	PHASE	SPECIES	1	2	3	4	5	6	OCCASION PUPAE/ADULT	OVERWINTER	EGG MASS SIZE
DAILY MORTALITY SOURCE											
BACKGROUND			.020	.020	.020	.020	.020	.020			
DISEASE	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	DF, GF	.000	.000	.000	.000	.001	.001			
	III	DF, GF	.002	.003	.006	.013	.035	.028			
	IV	DF, GF	.025	.028	.031	.034	.035	.035			
PARASITE/PREDATOR	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	DF, GF	.000	.000	.000	.000	.001	.001			
	III	DF, GF	.001	.002	.003	.010	.016	.042			
	IV	DF, GF	.005	.006	.007	.021	.033	.056			
STRESS	I, II, III, IV DF		.920	.600	.070	.000	.000	.000			
	I, II, III, IV GF		.950	.700	.100	.020	.000	.000			
CONTROL	I	DF, GF	.000	.000	.000	.000	.000	.000		.000	.000
	II	GF, DF	.000	.000	.000	.000	.000	.000		.000	.000
	III	GF, DF	.000	.000	.000	.000	.000	.000		.000	.000
	IV	GF, DF	.000	.000	.000	.000	.000	.000		.000	.000
LIFE STAGE MORTALITY											
	I	DF, GF							.500	.500	200.0
	II	DF, GF							.620	.600	200.0
	III	DF, GF							.750	.850	150.0
	IV	DF, GF							.800	.900	150.0
NOMINAL EGG MASS SIZE											
	I	DF, GF									
	II	DF, GF									
	III	DF, GF									
	IV	DF, GF									
DESTRUCTION/CONSUMPTION RATIOS											
NEW FOLIAGE			5.400	6.250	6.250	2.710	2.270	2.200			
OLD FOLIAGE			5.400	6.250	6.250	3.690	3.290	3.200			
MEAN INDIVIDUAL LARVAL GROWTH RATE			1.147	1.147	1.147	.9386	.0625	.0625			
REDISTRIBUTION COEFFICIENT FOR THE OUTBREAK			0.00								
PHASE SPECIFIC MEAN EGG DENSITY BY PHASE											

Table 4. First output table from simulation with control.

TREE CLASS NO.	NUMBER OF STEMS	PHASE I			PHASE II			PHASE III			PHASE IV		
		INPUTS		OUTPUTS		INPUTS		DEFOLIATION (%)	OUTPUTS		DEFOLIATION (%)	OUTPUTS	
		VIABLE EGGS (NO.)	TOTAL FOLIAGE BIOMASS (GRAMS)	PERCENT NEW FOLIAGE (%)	DEFOLIATION (%)	VIABLE EGGS LAID (NO.)	REDIS-TRIBUTED EGGS (NO.)		VIABLE EGGS LAID (NO.)	REDIS-TRIBUTED EGGS (NO.)		VIABLE EGGS LAID (NO.)	REDIS-TRIBUTED EGGS (NO.)
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
3	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
4	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
5	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

PHASE III													
PHASE IV													
1	.000	17.225	229.209	29.758	6.434	18.786	18.786	2.818	227.780	29.318	1.404	.505	.505
2	.000	25.838	228.813	29.637	9.651	28.179	28.179	4.227	226.671	28.972	2.106	.757	.757
3	.000	37.896	228.259	29.466	14.154	41.329	41.329	6.199	225.117	28.482	3.089	1.111	1.111
4	.000	51.676	227.626	29.270	19.301	54.357	54.357	8.454	223.341	27.913	4.212	1.515	1.515
5	.000	68.902	226.835	29.023	25.735	75.143	75.143	11.271	221.121	27.189	5.617	2.020	2.020

Table 5. Second output table from simulation with control.

TREE CLASS NO	NUMBER OF TREES	WEIGHT FACTOR PER TREE	INITIAL VIABLE EGGS	MODEL BRANCH: PERCENT DEFOLIATION BY PHASE				PERCENT OF TREE		PER CENT OF TREES RECEIVING:			
				I	II	III	IV	TOTALLY DEFOLIATED	TREE	DIRECT MORTALITY	SECONDARY MORTALITY	TOP KILL	ONLY GROWTH REDUCTION
1	.0	.0	.000	.000	2.294	6.434	1.404	.000		.0	4.4	5.6	90.0
2	.0	.0	.000	.000	3.441	9.651	2.106	.000		.0	4.4	5.6	90.0
3	.0	.0	.000	.000	5.046	14.154	3.089	.000		.0	4.4	5.6	90.0
4	.0	.0	.000	.000	6.882	19.301	4.212	.000		.0	4.4	5.6	90.0
5	.0	.0	.000	.000	9.175	25.735	5.617	.001		.0	4.4	5.6	90.0

TREE CLASS NO	NUMBER OF TREES	WEIGHT FACTOR PER TREE	INITIAL VIABLE EGGS	PER CENT OF TREES BY PERCENT REDUCTION IN CROWN HEIGHT				GROWTH IN SURVIVING TREES WITH NO TOP KILL		DIAMETER GROWTH IN TREES WITH TOP KILL	
				0.0	5.0	17.5	37.5	70.0	PERCENT OF NOMINAL DIAMETER HEIGHT	PERCENT OF NOMINAL	PERCENT OF NOMINAL
1	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
2	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
3	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
4	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
5	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00

Table 6. Third output table from simulation with control.

DESCRIPTION	PHASE	SPECIES	1	2	3	4	5	6	FUR/ADULT	OCCASION	EGG MASS
									OVERWINTER	SIZE	
DAILY MORTALITY SOURCE											
BACKGROUND	I, II, III, IV	DF, GF	.020	.020	.020	.020	.020	.020			
DISEASE	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	DF, GF	.000	.000	.000	.000	.001	.001			
	III	DF, GF	.002	.003	.006	.013	.035	.028			
	IV	DF, GF	.025	.028	.031	.034	.035	.035			
PARASITE/PREDATOR	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	DF, GF	.000	.000	.000	.000	.001	.001			
	III	DF, GF	.001	.002	.003	.010	.016	.042			
	IV	DF, GF	.005	.006	.007	.021	.033	.056			
STRESS	I, II, III, IV	DF	.920	.600	.070	.000	.000	.000			
	I, II, III, IV	GF	.950	.700	.100	.020	.000	.000			
CONTROL	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	GF, DF	.224	.000	.000	.000	.000	.000			
	III	GF, DF	.000	.000	.000	.000	.000	.000			
	IV	GF, DF	.000	.000	.000	.000	.000	.000			
LIFE STAGE MORTALITY	I	DF, GF							.500	.500	
	II	DF, GF							.620	.600	
	III	DF, GF							.750	.850	
	IV	DF, GF							.800	.900	
NOMINAL EGG MASS SIZE	I	DF, GF								200.0	
	II	DF, GF								200.0	
	III	DF, GF								150.0	
	IV	DF, GF								150.0	
DESTRUCTION/CONSUMPTION RATIOS											
NEW FOLIAGE	I, II, III	DF, GF	5.400	6.250	6.250	2.710	2.270	2.200			
OLD FOLIAGE	I, II, III	DF, GF	5.400	6.250	6.250	3.690	3.290	3.200			
MEAN INDIVIDUAL LARVAL GROWTH RATE	I, II, III	DF, GF	1147	1147	1147	.0386	.0625	.0625			
REDISTRIBUTION COEFFICIENT FOR THE OUTBREAK			.000								
PHASE SPECIFIC MEAN EGG DENSITY BY PHASE	I=	000	11=	000	111=	000	1V=	000			

Table 7. Detailed information from simulation with control.

TREE CLASS	NUMBER OF INSECTS INITIATION OF YEAR				NUMBER OF INSECTS START FIRST INSTAR				NUMBER OF INSECTS START SECOND INSTAR			
	SPECIES		ZNEW FOLIAGE		BIOMASS SPECIES		TOTAL FOL.		ZNEW FOLIAGE		TOTAL FOL.	
	GRAND		30.00		GRAND		230.000		30.00		230.000	
	I	II	III	IV	I	II	III	IV	I	II	III	IV
1.	.000	50.000	17.225	2.818	.000	50.000	17.225	2.818	.000	3.239	13.658	1.700
2.	.000	75.000	25.838	4.227	.000	75.000	25.838	4.227	.000	4.858	20.437	2.550
3.	.000	110.000	37.896	6.199	.000	110.000	37.896	6.199	.000	7.126	30.048	3.740
4.	.000	150.000	51.676	8.454	.000	150.000	51.676	8.454	.000	9.717	40.974	5.100
5.	.000	200.000	68.902	11.271	.000	200.000	68.902	11.271	.000	12.956	54.632	6.800

TREE CLASS	NUMBER OF INSECTS START THIRD INSTAR				NUMBER OF INSECTS START FOURTH INSTAR				NUMBER OF INSECTS START FIFTH INSTAR			
	SPECIES		ZNEW FOLIAGE		BIOMASS SPECIES		TOTAL FOL.		ZNEW FOLIAGE		TOTAL FOL.	
	GRAND		30.00		GRAND		230.000		30.00		230.000	
	I	II	III	IV	I	II	III	IV	I	II	III	IV
1.	.000	2.646	10.615	.985	.000	2.162	7.925	.547	.000	1.767	5.138	.256
2.	.000	3.970	15.922	1.477	.000	3.244	11.887	.821	.000	2.650	7.707	.384
3.	.000	5.822	23.352	2.166	.000	4.757	17.434	1.204	.000	3.887	11.303	.563
4.	.000	7.939	31.844	2.954	.000	6.487	23.774	1.642	.000	5.300	15.413	.768
5.	.000	10.586	42.459	3.938	.000	8.649	31.699	2.189	.000	7.067	20.551	1.024

TREE CLASS	NUMBER OF INSECTS START SIXTH INSTAR				NUMBER OF INSECTS END LARVAL STAGE-START PUPAL				NUMBER OF INSECTS ADULT FEMALES TO PRODUCE EGGS			
	SPECIES		ZNEW FOLIAGE		BIOMASS SPECIES		TOTAL FOL.		ZNEW FOLIAGE		TOTAL FOL.	
	GRAND		30.00		GRAND		230.000		30.00		230.000	
	I	II	III	IV	I	II	III	IV	I	II	III	IV
1.	.000	.708	1.251	.052	.000	.567	.501	.017	.000	.215	.125	.003
2.	.000	1.061	1.876	.079	.000	.850	.751	.025	.000	.323	.188	.005
3.	.000	1.597	2.752	.115	.000	1.247	1.102	.037	.000	.474	.276	.007
4.	.000	2.123	3.753	.157	.000	1.700	1.503	.050	.000	.646	.376	.010
5.	.000	2.830	5.004	.209	.000	2.267	2.004	.067	.000	.861	.501	.013

Table 7. (Continued)

TREE CLASS	NUMBER OF INSECTS BEFORE OVERWINTER MORTALITY				TOTAL FOL. BIOMASS
	SPECIES	ZNEW FOLIAGE	TOTAL FOL.	230.000	
	GRAND	30.00	III	IV	
	I	II	III	IV	
1.	.000	43.064	18.786	.505	
2.	.000	64.595	28.179	.757	
3.	.000	94.740	41.329	1.111	
4.	.000	129.191	56.357	1.515	
5.	.000	172.254	75.143	2.020	