Description of the Stand-Damage Model: Part of the Gypsy Moth Life System Model

J. J. Colbert
Katharine A. Sheehan
Abstract

This document describes the structure, organization, and mathematical formulations for the Stand-Damage Model (a component of the Gypsy Moth Life System Model) and the biological basis for these formulations. The model follows the life of a forest stand as represented by tree species and diameter classes. The user supplies the initial state by describing the trees that make up the stand by species and diameter class, and the defoliation history by species and canopy strata. Growth, mortality, and regeneration are modeled along with the effects of user-prescribed defoliation and stand-management actions. The appendices provide a full description of the logic and mathematics in the form of code listings, structure charts, and files.

The Authors

J. J. COLBERT has served since 1989 as a research scientist in the silvicultural options for the gypsy moth project at the Northeastern Forest Experiment Station, Morgantown, West Virginia. He received A.B. (1966), M.S. (1970), and Ph.D. (1975) degrees in mathematics. He worked 4 years at the National Reactor Testing Station, U.S. Atomic Energy Commission as a nuclear operations engineer and 3 years as research associate professor at Oregon State University before joining the USDA Forest Service in 1979. He was Research Coordinator and then Program Manager of the western component of the Canada/United States Spruce Budworms Program until 1985.

KATHARINE A. SHEEHAN is an entomologist with the USDA Forest Service's Pacific Northwest Region at Portland, Oregon. Formerly a research entomologist with the Northeastern Forest Experiment Station at Morgantown, she received a B.S. degree in conservation of natural resources in 1976 and a Ph.D. degree in entomological sciences in 1982 from the University of California at Berkeley.

Manuscript received for publication 14 June 1994

The computer program described in this publication is available on request with the understanding that the U.S. Department of Agriculture cannot assure its accuracy, completeness, reliability, and suitability for any other purpose than that reported. The recipient may not assert any proprietary rights thereto nor represent it to anyone as other than a Government-produced computer program. For information write to: RWU-4557, Northeastern Forest Experiment Station, USDA Forest Service, 180 Canfield Street, Morgantown, WV 26505-3101.

Internet e-mail address and World-Wide-Web site URL can be found in the "readme" file on the installation disk.

USDA FOREST SERVICE
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August 1995
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Group 1: TA1 = 0.0033033 \( n_i + 0.020426 (\Sigma D_i^2) + 0.0006776 (\Sigma D_i^3); \)
Group 2: TA2 = -0.027142 \( n_i + 0.024257 (\Sigma D_i^2) + 0.0015225 (\Sigma D_i^3); \)
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Introduction

The Gypsy Moth Life System Model (GMLSM) comprises three components: the stand model simulates tree growth and mortality; the gypsy moth model simulates gypsy moth population dynamics and the feeding and destruction of foliage, and a gypsy moth population's interactions with its natural enemies; the natural enemy component consists of several less complex models that describe the dynamics of individual natural enemy species or guilds. Here we describe the stand model in detail. This model simulates the growth of a single forest stand over time. It treats the stand as a single homogeneous spatial unit. It predicts the number and size of trees in a stand and, within the GMLSM, summarizes stand and tree information for use by other submodels. A separate version of the stand model, the Stand-Damage Model, is available as an independent program that is separate from the rest of the GMLSM. The Stand-Damage Model allows users to examine the effects of a specified defoliation pattern on stand growth and yield; the user can describe particular gypsy moth defoliation episodes or the implementation of particular stand cultural practices.

This document describes the stand model formulations, the basis and background for these formulations, and the code and data for implementing them. The companion User's Guide (Colbert and Racin 1995) provides instructions for installation and use of the model in a tutorial and reference format. The guide to the model's interface management system (Racin and Colbert 1995) provides details of software design and implementation used in the development of the user-interface for the model and the installation program.

Tree growth and mortality functions are based largely on JABOWA (Botkin et al. 1972), a distance-independent, individual-tree model that simulates a single stand. Botkin et al. (1972) presented parameters for several northeastern species, parameters for additional tree species are from Shugart and West (1977). JABOWA predicts annual diameter growth as a function of the optimal growth rate and indices that reflect crowding, shading, and suboptimal temperatures. For the Stand-Damage Model, the effects of defoliation on diameter growth also have been incorporated. Here, diameter growth is calculated not for individual sample trees but for all trees within a species-diameter class. From this growth increment, the number of stems that will be reassigned to the next larger diameter class within the species is calculated. Tree mortality in JABOWA is predicted using a base or background mortality rate plus additional mortality that is simulated when diameter growth is incremented. These mortality sources plus additional mortality that occurs during periods of defoliation (especially if other stresses such as drought occur concurrently with defoliation) are included in the Stand-Damage Model.

The model has been developed over the past several years. It was initially designed as a component of the GMLSM. Following a series of development workshops in 1984, the model was turned over to the USDA Forest Service for additional work. The final report of this initial development is available.1 This initial model lacked many of the current details and was modified extensively (Sheehan 1989; Colbert 1991). The completion of the model in its current form has proceeded under the direction of Forest Service scientists and cooperators.

Parameter values are taken from the literature as cited or set arbitrarily (and noted as such) in accordance with the best estimates of numerous experts who took part in one or more of the series of workshops and meetings held to design the model. Default values are given in parentheses following single-parameter definitions or in tabular form for arrays or matrices of subscripted parameters. Code listings are provided for review of organization and structural details and the order and method of computations. When questions arise as to particular auxiliary or intermediate values or how variables change within a year, the DEBUG option selected from the output options section of the user interface (see the User's Guide for details) allows the user to produce output of intermediate calculations.

1McNamee, Peter J.; Bunnell, Pile; Jones, Michael L.; Marmorek, David R. 1983. Final report of a project to identify and evaluate important research questions for the gypsy moth life system. Environmental and Social Systems Analysts Ltd. for Adaptive Environmental Assessments, Inc. On file at USDA Forest Service, Northeastern Forest Experiment Station, RWU-4557, 180 Canfield St., Morgantown, WV 26505-3101.
Structure and Organization

Spatial and Temporal Resolution and Scope

The Stand-Damage Model simulates the annual establishment, growth, and mortality of trees by species and diameter class within a single forest stand. Variables are updated annually. Growth of a stand for up to 100 years can be projected. The stand is assumed to be spatially homogeneous with regard to density, species composition, and site conditions. The spatial distribution of trees within a stand is not modeled explicitly. Simulating a stand containing spatially aggregated clusters of preferred species would be identical to that for a stand containing randomly scattered preferred species so long as the number of trees in each diameter class by species remained the same (other factors being equal). Spatially inhomogeneous units should be subdivided so that each unit is relatively homogeneous. Each unit should then be treated as a separate stand.

All calculations are performed on a per-unit-area basis. The user is asked to supply the area sampled so that the initial numbers of trees can be converted to number of trees per unit area. Stand area is carried only for reporting purposes and does not affect calculations. Metric or English units can be specified for input and output. We have chosen English units as the default; these are used in the transfer from the user interface to the model proper. Units are converted automatically to the appropriate form for calculations during the simulation and then back to English units for output. If metric units are selected, all output is converted to metric before it is written to disk.

Representing Trees

Trees within a stand are grouped by species and diameter class; these groups are treated as individual cells. Up to 12 tree species or species groups can be included in a simulation. Parameters for 21 tree species and a user-defined (UD) group are provided in the user interface (Tables 1-5). Users also can supply values for other species or species groups or redefine a species by changing the defaults. For each tree species, up to 20 diameter classes can be simulated. By default, 2-inch-diameter classes are used; all classes start at 0.0, so the first diameter class has midpoint equal to half the class width. Tree growth and mortality are predicted separately for each diameter class of each species. Within a given species and diameter class, all trees are assumed to be identical.

Table 1.—Twenty-two tree species that can be included in a stand for simulation

<table>
<thead>
<tr>
<th>Species code</th>
<th>Survey code</th>
<th>Common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>WO</td>
<td>802</td>
<td>White oak</td>
<td>Quercus alba L.</td>
</tr>
<tr>
<td>SO</td>
<td>806</td>
<td>Scarlet oak</td>
<td>Quercus cocinea Muenchh.</td>
</tr>
<tr>
<td>CO</td>
<td>832</td>
<td>Chestnut oak</td>
<td>Quercus prinus L.</td>
</tr>
<tr>
<td>RO</td>
<td>833</td>
<td>Northern red oak</td>
<td>Quercus rubra L.</td>
</tr>
<tr>
<td>BO</td>
<td>833/</td>
<td>Black oak</td>
<td>Quercus velutina Lam.</td>
</tr>
<tr>
<td>RM</td>
<td>316</td>
<td>Red maple</td>
<td>Acer rubrum L.</td>
</tr>
<tr>
<td>SM</td>
<td>318</td>
<td>Sugar maple</td>
<td>Acer saccharum Marsh.</td>
</tr>
<tr>
<td>ST</td>
<td>315</td>
<td>Striped maple</td>
<td>Acer pensylvanicum L.</td>
</tr>
<tr>
<td>YR</td>
<td>371</td>
<td>Yellow birch</td>
<td>Betula alleghaniensis Ritteron</td>
</tr>
<tr>
<td>PB</td>
<td>375</td>
<td>Paper birch</td>
<td>Betula papyrifera Marsh.</td>
</tr>
<tr>
<td>SB</td>
<td>372</td>
<td>Sweet birch</td>
<td>Betula lenta L.</td>
</tr>
<tr>
<td>AB</td>
<td>531</td>
<td>American beech</td>
<td>Fagus grandifolia Ehrh.</td>
</tr>
<tr>
<td>BW</td>
<td>951</td>
<td>American basswood</td>
<td>Tilia americana L.</td>
</tr>
<tr>
<td>YP</td>
<td>621</td>
<td>Yellow-poplar</td>
<td>Liriodendron tulipifera L.</td>
</tr>
<tr>
<td>FD</td>
<td>491</td>
<td>Flowering dogwood</td>
<td>Cornus florida L.</td>
</tr>
<tr>
<td>AS</td>
<td>746</td>
<td>Quaking aspen</td>
<td>Populus tremuloides Michx.</td>
</tr>
<tr>
<td>BC</td>
<td>762</td>
<td>Black cherry</td>
<td>Prunus serotina Ehrh.</td>
</tr>
<tr>
<td>WA</td>
<td>541</td>
<td>White ash</td>
<td>Fraxinus americana L.</td>
</tr>
<tr>
<td>HI</td>
<td>400</td>
<td>Hickory spp.</td>
<td>Carya spp.</td>
</tr>
<tr>
<td>WP</td>
<td>129</td>
<td>Eastern white pine</td>
<td>Pinus strobus L.</td>
</tr>
<tr>
<td>BG</td>
<td>693</td>
<td>Blackgum (black tupelo)</td>
<td>Nyssa sylvatica Marsh.</td>
</tr>
<tr>
<td>UD*</td>
<td>000</td>
<td>User defined</td>
<td></td>
</tr>
</tbody>
</table>

*Modal values provided for all parameters of user-defined species; range-checking values are similar for all parameters of all tree species.
Weather

The stand model uses annual degree-days to modify annual diameter growth for each tree species (Everson et al. 1976). When using the Stand-Damage Model, users can supply the annual total degree-days for each year. By default, a constant value is supplied for each year. When the length of a simulation or the starting year is changed, the sequence of annual degree-day totals are not resequenced automatically and may need to be adjusted. If the GMLSM is used, the Gypsy Moth Model requires daily weather data or parameters for stochastically generated weather; in this situation, the annual summary datum is calculated from these daily data for each year.

Communication with Gypsy Moth Model

The stand model summarizes stand information by species and strata for other submodels of the GMLSM. These stand attributes, such as potential foliage biomass and the number of resting sites, are updated annually for each species and stratum. Five strata are recognized for each species:

- Foliage from overstory trees,
- Foliage from understory trees,
- Foliage from shrubs and ground cover,
- Lower boles of overstory trees,
- Upper boles and branches of overstory trees together with boles and branches of understory trees.

Oversory and understory trees can be categorized on the basis of diameter or height. By default, trees larger than 6 inches in diameter at breast height (d.b.h.) are considered overstory trees. Both the breakpoint and method can be changed by the user.

The Gypsy Moth Model returns the defoliation each year, using this same stratification. No adjustments are made within the stand model for timing of foliage consumption or the fact that foliage growth and consumption have taken place simultaneously.

Management Actions

Annual silvicultural treatments can be scheduled by the user prior to executing a simulation. For each stand-management entry, the user specifies the year that an action is to take place and the method to be used. With these options, the user can specify standard treatments such as thinning from below or above, and can explore alternatives for reducing gypsy moth damage, for example, reducing the proportion of preferred host tree species in the stand.

When using the proportional cut method, one provides separately for each species a proportion to be removed as well as the diameter limits within which to operate. The proportion of the stem count within each diameter class that falls between the specified diameter limits is removed.

When the target method is specified, the user supplies diameter limits and a target number of stems for each species to remain following the removal. In this instance, the total count for all diameter classes and the total count for the diameter classes that fall within the diameter limits are accumulated for each species. The target count is first reduced by the total count outside the diameter limits. Then an equal proportion of the stems from each diameter class that falls within the cut limits provided is removed. Thus, the total stem count outside the limiting diameters added to the remainder inside equals the specified target. In some instances, there may be sufficient stem counts to reach the prescribed targets outside the diameter limits provided. Should this occur, all diameter classes within the limits will be emptied yet still leave more than the prescribed residual outside the limits. At the opposite extreme, if the residual prescribed is above the current stocking for a species, no trees are removed for that species.

Using the Stand-Damage Model, the effects of direct control of gypsy moth populations can be simulated by assigning defoliation rates that reflect the assumed effectiveness of the control efforts. For example, to compare the effectiveness of controlling gypsy moth at different years during an outbreak, the user would supply different defoliation scenarios that are assumed to result from the different control strategies. The full GMLSM allows the user
to examine, in much greater detail, the results of spray suppression on gypsy moth, its natural enemies, and consequential foliage dynamics, as well as the tree growth and mortality effects that are simulated in the Stand-Damage Model. Using the GMLSM, the user would supply suppression timing and insecticide mortality rate data. The models would then project the effects of those suppression tactics, carrying the results through to altered defoliation scenarios.

Information Required

The information needed to use the Stand-Damage Model is summarized in Table 2. The initial number of stems by species and diameter, total area of sample plots, and site moisture (wet, moderate, or dry) are required to describe a stand. Other information is optional. Default values are supplied for initial conditions and parameters (Tables 3-6); these will be used if specific values are not supplied. Data on average annual temperature (degree-day total for years) can greatly affect tree dynamics. All information can be accessed through the user-friendly access and control portion of the program that provides a means to input or modify initial conditions and parameters, and to select desired output tables and graphs. There is a full default stand provided when the access and control section is initiated, and an additional complete example stand. See the User’s Guide (Colbert and Racin 1995) for instructions. If you are interested in the program that generated the access facility, see the guide to the interface management system (Racin and Colbert 1995).

Table 2.—Required and optional information used by Stand-Damage Model (all data have initial default values supplied by user-interface software)

<table>
<thead>
<tr>
<th>Required</th>
</tr>
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<tbody>
<tr>
<td>Initial Stand Conditions</td>
</tr>
<tr>
<td>Number of trees in stand, by species and diameter class</td>
</tr>
<tr>
<td>Prior defoliation (4 percentage classes) by species and canopy strata</td>
</tr>
<tr>
<td>Stand Data</td>
</tr>
<tr>
<td>Sample plot area</td>
</tr>
<tr>
<td>Stand area</td>
</tr>
<tr>
<td>Soil-moisture category (mesic, intermediate, or xeric)</td>
</tr>
<tr>
<td>Number of years to be simulated</td>
</tr>
<tr>
<td>Optional</td>
</tr>
<tr>
<td>Weather Data (either a or b):</td>
</tr>
<tr>
<td>a. Total annual degree-days</td>
</tr>
<tr>
<td>b. When used as part of the GMLSM, daily maximum and minimum temperatures (for at least 1 year)</td>
</tr>
<tr>
<td>Output Options</td>
</tr>
<tr>
<td>Format</td>
</tr>
<tr>
<td>Intervals at which output is to be produced</td>
</tr>
<tr>
<td>Units (metric or English)</td>
</tr>
<tr>
<td>Stand Structure</td>
</tr>
<tr>
<td>Number of diameter classes</td>
</tr>
<tr>
<td>Length (and midpoint) of diameter classes</td>
</tr>
<tr>
<td>Boundary that separates overstory and understory canopy strata</td>
</tr>
<tr>
<td>Defoliation (percent by species and crown position for each year)</td>
</tr>
<tr>
<td>Tree Attributes</td>
</tr>
<tr>
<td>Maximum diameter, height, and age</td>
</tr>
<tr>
<td>Height parameters</td>
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<tr>
<td>Foliage parameters</td>
</tr>
<tr>
<td>Shade-tolerance class (for diameter growth and recruitment)</td>
</tr>
<tr>
<td>Diameter-Growth Modifiers</td>
</tr>
<tr>
<td>Shading parameters</td>
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<tr>
<td>Temperature parameters</td>
</tr>
<tr>
<td>Relative stand density parameters</td>
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<tr>
<td>Defoliation parameters</td>
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<td>Base growth-rate parameter</td>
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<tr>
<td>Tree-Mortality Parameters</td>
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<tr>
<td>Effects of defoliation</td>
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<td>Effects of other stress agents</td>
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<td>Stem Recruitment</td>
</tr>
<tr>
<td>Maximum recruitment</td>
</tr>
<tr>
<td>Shading parameters</td>
</tr>
</tbody>
</table>
Information Produced

There are a number of output files that the user can view and, if desired, permanently archive to disk. The summary table is the only output file that is produced by default. It contains information provided by the user relating the source data to the output, a full listing of the parameters and initial conditions for the simulation, and summary output by year. The user can schedule the years for which output should be produced. Detailed descriptions of the output file formats follow the description of the model formulation.

Overview: Sequence of Steps

Figure 1 shows the sequence of steps performed by the Stand-Damage Model during a simulation. As soon as parameters and initial conditions are read into the program, the information header and all initial output are written to temporary disk files. These include a complete description of the data used in the simulation.

Figure 1: Flowchart for Stand-Damage Model. Equation numbers are given in parentheses at places where they are calculated.
Because Equations 1-4 and 17 are not dependent on time-varying parameters or variables, for numerical efficiency these values are calculated once at the start of the simulation. Tree height is dependent on diameter, but diameter for each species-diameter cell is known at the start, and the height is calculated once for each cell using the cell midpoint diameter, regardless of the number of trees occupying that cell.

At the start of each year, two items are calculated for each diameter class of each species: the amount of foliage that would be produced per tree if no defoliation were to occur, and the number of resting sites available to gypsy moths per tree. As part of the GMLSM, these data are passed to the gypsy moth model. Defoliation estimates are retrieved, either from the gypsy moth model or, in the case of the Stand-Damage Model, from a file created by the program to store information provided by the user. Next, intermediate variables used to estimate tree growth are calculated. These equations use the variable values for the previous year along with associated parameters to develop the precursors to and components of diameter growth and tree mortality. Tree growth, mortality, and stem recruitment are then simulated. Next, growth increments are translated to changes in the number of stems in each diameter class, followed by removals from prescribed stand-management entries.

**Stand-Damage Model Calculations Prior to Defoliation**

Several stand variables are calculated each year before defoliation by gypsy moth is simulated. These variables are used by the gypsy moth model. Some of these variables also are used later by the stand model for predictions of tree growth, mortality, and recruitment.

**Annual Degree-Days**

The total annual heat input (degree-days) experienced by trees is estimated for each year as the sum of the daily degree days that occurred during that year. Daily degree days are calculated from maximum and minimum temperatures as shown in Equation 1 (from Arnold 1959):

\[
DDAYS_{j} = \max\left\{ \frac{TMAX_{j} + TMIN_{j}}{2.0}, TREMIN, 0 \right\}
\]

\[
ANND = \sum_{j=1}^{365} DDAYS_{j}
\]  

where:

- \(DDAYS_{j}\) = degree-days (°F) experienced by trees on day \(j\),
- \(TMAX_{j}\) = maximum temperature (°F) on day \(j\),
- \(TMIN_{j}\) = minimum temperature (°F) on day \(j\),
- \(TREMIN\) = threshold temperature for tree development (42°F),
- \(ANND\) = accumulated degree-days for the year.

All tree species have the same default threshold temperature but the user can adjust these values for any tree species. In the gypsy moth model, species-specific thresholds also are used when simulating the timing of budbreak and leaf expansion and gypsy moth development. If the user has provided temperatures in metric units, the temperatures and the development threshold will be converted to degrees Fahrenheit for use within the model, then converted back to metric units for output. When the stand model is accessed as a stand-alone system, daily temperature details are not required and only the annual sums are used. These annual totals are used to modify annual diameter-growth rates and defaults are accessible for user modification.

**Tree Heights**

The heights of trees are calculated using species-specific parameters and the midpoint of each of the diameter class (Kein and Smith 1955):

\[
HEIGHT_{h,d} = DBHHT + B_{1h} \times DIAM_{d} - B_{2h} \times DIAM_{d}^2
\]  

\[
(2)
\]
where:

\[ \text{HEIGHT}_{h,d} = \text{height (cm) of diameter class } d \text{ of species } h, \]
\[ \text{DRHHT} = \text{breast height (137 cm),} \]
\[ \text{DIAM}_{h} = \text{mean diameter (cm) of diameter class } d, \]
\[ B_{1_h}, B_{2_h} = \text{height growth parameters for species } h. \]

DBHHT is fixed at the mensuration standard and not available for redefinition by users. Following Botkin et al. (1972), \( B_{1_h} \) and \( B_{2_h} \) values were chosen so that when the maximum diameter (\( \text{DMAX}_h \)) has been reached, tree height equals the maximum tree height (\( \text{HMAX}_h \)) and height growth ceases. These conditions are met when:

\[ B_{1_h} = 2 \times \frac{\text{HMAX}_h \cdot \text{DBHHT}}{\text{DMAX}_h} \]  \hspace{1cm} (3)
\[ B_{2_h} = \frac{\text{HMAX}_h \cdot \text{DBHHT}}{\text{DMAX}_h^2} \]  \hspace{1cm} (4)

where:

\[ \text{HMAX}_h = \text{maximum height (cm) for species } h, \]
\[ \text{DMAX}_h = \text{maximum diameter (cm) at breast height for species } h, \]
\[ \text{DBHHT} = \text{breast height (cm).} \]

Default values for \( \text{HMAX}_h \) and \( \text{DMAX}_h \) were taken from Harlow et al. (1979), and were used with Equations 3 and 4 to calculate the values for \( B_{1_h} \) and \( B_{2_h} \) (Table 3). If the diameter is above \( \text{DMAX}_h \), tree height is modified from the value given by Equation 2; in this case, the height is reset to \( \text{HMAX}_h \).

### Table 3. Parameters for maximum diameter, height, and age along with associated parameters for height equation

<table>
<thead>
<tr>
<th>Species code</th>
<th>Maximum diameter*</th>
<th>Maximum height</th>
<th>Height parameters*</th>
<th>Maximum age*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TNAME&lt;sub&gt;h&lt;/sub&gt;</td>
<td>DMAX&lt;sub&gt;h&lt;/sub&gt;</td>
<td>HMAX&lt;sub&gt;h&lt;/sub&gt;</td>
<td>( b_{1_h} )</td>
<td>( b_{2_h} )</td>
</tr>
<tr>
<td><strong>Inches</strong></td>
<td><strong>Feet</strong></td>
<td><strong>Years</strong></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.196</td>
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<td>80</td>
<td>50.35</td>
<td>0.275</td>
</tr>
<tr>
<td><strong>CO</strong></td>
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<td>60</td>
<td>55.48</td>
<td>0.455</td>
</tr>
<tr>
<td><strong>RO</strong></td>
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<td>0.275</td>
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<tr>
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</tr>
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<td>55.48</td>
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<td>0.455</td>
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<td>0.275</td>
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<td>50.35</td>
<td>0.275</td>
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<tr>
<td><strong>HI</strong></td>
<td>24</td>
<td>70</td>
<td>65.48</td>
<td>0.537</td>
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</table>

*Heights and diameters reported by Harlow et al. (1979) for mature trees except ST was assigned values for FD; when a range was given for heights or diameters, the upper boundary was used.

*Calculated using maximum height and diameter (listed in this table) in Equations 3 and 4.

*Maximum ages reported by Harlow et al. (1979) except CO (assigned values of RO) and BW (assigned values of BC).
Overstory Versus Understory Trees

Individual-tree characteristics such as basal area, foliage biomass, and number of resting sites are summarized across diameter classes into overstory and understory totals by species for use by the gypsy moth model. Height or diameter can be used to separate overstory from understory trees, and the user can specify the boundary height or diameter. By default, trees less than 6 inches in d.b.h are classified as understory. This point of division is chosen before initiating a simulation and is used throughout the simulation. As a fixed parameter, it does not reflect the dynamic of this break point as is sometimes assumed. Non-tree understory vegetation is not considered in the Stand-Damage Model, but will be described in the gypsy moth model as it only affects and is affected by gypsy moth larval feeding.

Foliage Biomass

Foliage biomass is calculated for each diameter class and species using the allometric function:

\[ FOLIAG_{h,d} = F_{1h} \times DIAM^2_{h,d} \times STEMS_{h,d} \]  

(5)

where:

- \( FOLIAG_{h,d} \) = foliage biomass (kg/ha dry weight) in diameter class d for species h,
- \( F_{1h}, F_{2h} \) = foliage biomass parameters for species h,
- \( STEMS_{h,d} \) = number of trees per hectare (ha) in diameter class d of species h.

Default values for \( F_{1h} \) and \( F_{2h} \), shown in Table 4 were derived from the literature. Each published curve was used to generate five data points spanning the range of the data that originally were used to generate the curve. The newly generated data were then combined to form a set used to fit the allometric relationship of Equation 5. For each species, foliage biomass also is summed for overstory and understory crown classes and converted to grams for use by the gypsy moth model. Foliage is summed in overstory (FOLh_o) and understory (FOLh_u) variables for each tree species (h). Adjustments are then made for the effect of prior defoliation on current production. The defoliation in this cell last year (DEFLh), expressed as a proportion, times a rate constant (DFOLDE = 0.15) is used to reduce this maximum: [1.0-DFOLDE(DEFL/100.0)]. This adjusted value is then used by the gypsy moth model as the asymptotic maximum foliage produced that year. In that model FOLh is used as the base to estimate foliage growth, consumption, and defoliation, while in the Stand-Damage Model, it is used as the base for estimating the effects of user-supplied defoliation.

Live Crown Ratio

The live crown ratio (live crown to total tree height) is calculated using a model developed by Holdaway (1986) that uses four species-specific parameters (Table 5) and has two main components—the effect of competition for light within the stand, represented by stand basal area, and the effect of an individual tree’s competitive position, as indicated by diameter:

\[ CROWN_{h,d} = \left[ \frac{l_h}{1.0 + CR2_h \times BA} + CR3_h \times (1.0 - e^{-CR4_h \times DIAM_d}) \right] \]  

(6)

where:

- \( CROWN_{h,d} \) = live crown ratio for diameter class d of species h,
- \( CR1_h, CR4_h \) = crown-ratio parameters (Table 5),
- \( BA \) = total stand basal area (ft² per acre),
- \( DIAM_d \) = d.b.h. (inches) for diameter class d.

Using the live crown ratio, each overstory tree is separated into components of two strata—boles and live crowns—for use by the gypsy moth model. Live crown ratio will also be used to calculate the total number of larval resting sites (Equation 7); the number of resting sites in each strata is calculated separately.
Table 4.—Shade-tolerance classes, stocking group, and foliage and resting-site parameters for each tree species

<table>
<thead>
<tr>
<th>Species code</th>
<th>Tolerance class&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Diam. growth</th>
<th>ISTOKG&lt;sub&gt;n&lt;/sub&gt;</th>
<th>F&lt;sub&gt;1&lt;/sub&gt;</th>
<th>F&lt;sub&gt;2&lt;/sub&gt;</th>
<th>No. of resting sites/m&lt;sup&gt;2&lt;/sup&gt; of bark surface area&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Boles</th>
<th>Crown</th>
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<td>3</td>
<td>3</td>
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<td>1.7284</td>
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<td>1.7751</td>
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<td>RO</td>
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<td>6</td>
<td>2</td>
<td>0.0262</td>
<td>1.7751</td>
<td>0.05</td>
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<tr>
<td>BO</td>
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<td>2</td>
<td>3</td>
<td>0.0157</td>
<td>2.0000</td>
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<tr>
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<td>5</td>
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<td>2.0149</td>
<td>0.10</td>
<td>0.01</td>
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<td>4</td>
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<td>2.0601</td>
<td>0.01</td>
<td>0.10</td>
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<tr>
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<td>4</td>
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<td>2.0149</td>
<td>0.01</td>
<td>0.10</td>
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<td>2.1717</td>
<td>0.05</td>
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</table>

<sup>a</sup> 1 = intolerant, 2 = intolerant-intermediate, 3 = tolerant-intermediate, 4 = tolerant, 5 = red maple (growth loss: like tolerant class at low light availability, like intolerant class at high light; recruitment: like intolerant at low relative stocking, like tolerant at high relative stocking), 6 = red oak (growth loss: like intermediate-intolerant at low light availability, like intolerant at high light; recruitment: same as intolerant-intermediate).

<sup>b</sup> From Stout et al. (1987).

Table 5.—Parameter values for calculating live crown ratio (Equation 6)

<table>
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<td>0.0040</td>
<td>2.50</td>
<td>0.025</td>
</tr>
</tbody>
</table>

<sup>a</sup> Source: Holdaway (1986), with the following exceptions (for species not included in Holdaway 1986): CO is assigned the values of WO; SO and BO are assigned the values of RO; ST and FD are assigned the values of RM; AB is assigned the values of SM; BG is assigned the values of AS; SB is assigned the values of PB; and BC and YP are assigned the values of WA.
Resting Sites

The number of resting sites present bark flaps or crevices and other locations where gypsy moth might avoid predators or parasites while in a larval resting phase or as pupae—is estimated for each diameter class by species. The total represents the number of resting sites that could be occupied by first-instar larvae, and will be adjusted later by the gypsy moth model to account for the effect of larval size on resting-site suitability. The number of resting sites is assumed to be a function of bark surface area and tree species:

\[
RSITES_{h,s} = \sum_{d,s} STEMSC_{h,d} \times \frac{\text{RESTING}_{h,s,i}}{10,000} \times \frac{\pi \times DIAM_{d}}{2.0} \times \sqrt{\frac{DIAM_{d}^2 + HEIGHT_{h,d}^2}{4.0}}
\]

where:

- \(RSITES_{h,s}\) = maximum number of resting sites found on a tree of species hend canopy strata s,
- \(\text{RESTING}_{h,s,i}\) = resting-site index: number of resting sites per m² of bark surface area (c = 1 for boles, c = 2 for crowns, see Table 2),
- 10,000 cm² = 1 m²,
- \(\pi\) = \(\pi\) = 3.14159,
- \(DIAM_{d}\) = d.b.h. (cm) of diameter class d,
- \(HEIGHT_{h,d}\) = height (cm) of diameter class d of species h (Equation 1).

The first summation in Equation 7 is over all diameter classes (d) that fall within the crown strata (s). The number of resting sites is summed separately for overstory and understory (canopy strata s = 2) trees for each species for use by the gypsy moth model. Resting sites on overstory trees are further partitioned to crown (s = 1) and bole (s = 4) according to the live crown ratio. For understory trees, \(HEIGHT_{h,d}\) and \(\text{CROWNRC}_{h,s}\) is substituted for \(HEIGHT_{h,d}\) in Equation 7 to calculate the number of resting sites in the crowns. In calculating resting sites for the boles of overstory trees, it is assumed that bole is a right circular cylinder. Resting sites play no role in the dynamics of trees and are used only when the stand submodel is linked to the gypsy moth submodel in the full GLMSM. The final strata considered (s = 3) is the ground and non-tree understory vegetation which, again, is relevant only to the linked model.

Relative Stocking

Relative stocking is an indicator of stand density (Stout et al. 1987). Tree species are assigned to one of three categories according to their influence on stand density (Table 4), and the total number of stems in each stocking class is used to calculate relative stocking for the stand:

\[
RSTOCK = \sum_{s,t}^{S^{UM}} \sum_{d,t}^{T^{UM}} TOT_{d,t} \times [S_{s,t} + S_{s,d} \times DIAM_{d} + S_{s,d} \times DIAM_{d}^2]
\]

where:

- \(RSTOCK\) = relative-stocking index for the stand,
- \(TOT_{d,t}\) = total number of stems per acre in diameter class d and stocking class s,
- \(S_{s,t}, S_{s,d}, S_{s,d}\) = relative-stocking parameters for species group s,
- \(DIAM_{d}\) = d.b.h. (inches) for diameter class d,
- \(NDIAM\) = number of diameter classes.

The stocking parameters reported by Stout et al. (1987), shown in Figure 2, are used by default. Relative stocking is used later in the Stand-Damage Model to calculate both annual diameter growth and recruitment of new trees to the smallest diameter class. Parameters \(S_{s,d}\) are implemented in the code as STOcks(s,i).
Defoliation

Annual defoliation estimates for both overstory and understory trees of each species can be supplied by the user. As part of the full GMLSM, they are generated by and passed from the gypsy moth submodel each year, depending on species-specific feeding preference (Mosher 1915). In this case, the stand submodel assesses the potential foliage biomass to the gypsy moth submodel at the start of each year. Both diameter growth and tree mortality are affected by multiyear defoliation histories. Three years' (current and past two) defoliation are combined to determine current effects.

The defoliation history by strata for the 2 years prior to the first year of the simulation is a user-definable initial condition that is set to zero by default. For each tree species, the amount of foliage present in each canopy strata (and hence all associated diameter classes) is reduced in proportion to the defoliation percentage that was supplied for that canopy strata. The resulting changes in foliage distribution within the stand indirectly affect diameter growth by influencing the shading index. Defoliation also affects diameter growth directly through the defoliation index; both indices are described in the next section. A 2-year defoliation scenario is provided as part of the defaults for the Stand-Damage Model.
Diameter Growth

Annual diameter growth in the JABOWA model is assumed to be a function of the maximum growth rate as modified by crowding, temperatures, and shading factors (Botkin et al. 1972). For the Stand-Damage Model, the functions that describe the three growth modifiers have been revised, and a fourth factor has been added that accounts for the direct effect of defoliation on growth.

Shading

Following Botkin et al. (1972), the effect of shading on tree growth is assumed to be a function of the amount of light available to the tree and the tree's degree of shade tolerance. For each diameter class of each species, the total amount of foliage biomass per hectare for all taller trees is summed and then adjusted to reflect the assumed area of influence for each tree:

\[ \text{SUMFOL}_{h,d} = \text{PLOTSZ} \times \sum_{h=1}^{\text{HOSTS}} \sum_{d=1}^{\text{DIAM}} \text{STEMS}_{h,d} \times \text{FOLIAG}_{h,d} \]  

where:

- \( \text{SUMFOL}_{h,d} \) = amount of foliage (kg) assumed to influence diameter class \( d \) of species \( h \) through shading,
- \( \text{PLOTSZ} \) = total area surrounding a tree that is assumed to affect the shading of that tree (0.833 ha),
- \( d_i \) = smallest diameter class that is taller than diameter class \( d \) of host \( h \),
- \( \text{FOLIAG}_{h,d} \) = foliage biomass (kg dry weight) on a tree of diameter class \( d \) and species \( h \) (Equation 5), adjusted for defoliation if appropriate,
- \( \text{STEMS}_{h,d} \) = number of stems per ha for diameter class \( d \) and species \( h \).

PLOTSZ has been set in accordance with the procedure described by Botkin (1993); shading leaf area of surrounding trees (implemented as SUMLFA in the code) must be rescaled from the standard units of biomass on a trees/ha basis. The amount of foliage influencing a given tree is then used to calculate the amount of light available to that tree:

\[ \text{ALIGHT}_{h,d} = \text{TLIGHT} \times e^{\text{TKL} \times \text{SUMFOL}_{h,d} \times \text{SURFAR}_h} \]  

where:

- \( \text{ALIGHT}_{h,d} \) = available light for diameter class \( d \) of species \( h \),
- \( \text{TLIGHT} \) = annual insolation factor (1.0),
- \( \text{TKL} \) = a shading coefficient (0.0002),
- \( \text{SUMFOL}_{h,d} \) = amount of foliage biomass that is influencing a tree in diameter class \( d \) of species \( h \) (Equation 11),
- \( \text{SURFAR}_h \) = ratio of leaf surface area to biomass (cm² per kg dry weight) for species \( h \).

Local geography and topographic position could be used to improve this relationship using latitude, slope, and aspect to adjust TLIGHT (Botkin et al. 1972). TKL has been set arbitrarily in accordance with the assumed area of influence (PLOTSZ, viz. Botkin et al. 1972). Calculations of ALIGHT using this default value for TLIGHT and three values of TKL are shown in Figure 3 for a range of values of total Shading Leaf Area, \( \text{SLA} = \text{SUMFOL}_{h,d} \times \text{SURFAR}_h \). Default values for SURFAR, are listed in Table 6.
Table 6.—Parameters for diameter growth, heat range, leaf area, and recruitment

<table>
<thead>
<tr>
<th>Species code</th>
<th>Max. diameter growth ratea</th>
<th>Diam. growth parameterb</th>
<th>Range in annual degree-daysc</th>
<th>Leaf area to biomass ratiod</th>
<th>Max. number of stems recruited per yeare</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inches/yr</td>
<td>inches/in2/oz</td>
<td>GROWR&lt;sub&gt;n&lt;/sub&gt;</td>
<td>COLD&lt;sub&gt;n&lt;/sub&gt;</td>
<td>HOT&lt;sub&gt;n&lt;/sub&gt;</td>
</tr>
<tr>
<td>WO</td>
<td>0.262</td>
<td>83.3</td>
<td>2,966</td>
<td>10,204</td>
<td>597.6</td>
</tr>
<tr>
<td>SO</td>
<td>--</td>
<td>82.0</td>
<td>4,105</td>
<td>8,499</td>
<td>457.0</td>
</tr>
<tr>
<td>CO</td>
<td>--</td>
<td>83.3</td>
<td>3,686</td>
<td>7,756</td>
<td>628.4</td>
</tr>
<tr>
<td>RO</td>
<td>0.359</td>
<td>21.5</td>
<td>731</td>
<td>8,499</td>
<td>457.0</td>
</tr>
<tr>
<td>BO</td>
<td>0.323</td>
<td>82.0</td>
<td>3,313</td>
<td>9,461</td>
<td>593.2</td>
</tr>
<tr>
<td>RM</td>
<td>0.437</td>
<td>194.4</td>
<td>1,810</td>
<td>13,395</td>
<td>900.8</td>
</tr>
<tr>
<td>SM</td>
<td>0.293</td>
<td>164.1</td>
<td>1,522</td>
<td>7,366</td>
<td>900.8</td>
</tr>
<tr>
<td>ST</td>
<td>--</td>
<td>164.1</td>
<td>1,522</td>
<td>7,366</td>
<td>900.8</td>
</tr>
<tr>
<td>YB</td>
<td>0.179</td>
<td>63.7</td>
<td>731</td>
<td>7,366</td>
<td>1010.6</td>
</tr>
<tr>
<td>PB</td>
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<td>6,391</td>
<td>1010.6</td>
</tr>
<tr>
<td>SB</td>
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<td>95.2</td>
<td>3,686</td>
<td>7,366</td>
<td>1010.6</td>
</tr>
<tr>
<td>AB</td>
<td>0.238</td>
<td>70.5</td>
<td>2,057</td>
<td>10,204</td>
<td>1111.7</td>
</tr>
<tr>
<td>BW</td>
<td>0.125</td>
<td>42.3</td>
<td>5,526</td>
<td>8,499</td>
<td>1111.7</td>
</tr>
<tr>
<td>YP</td>
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<td>338.1</td>
<td>3,686</td>
<td>10,947</td>
<td>799.7</td>
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<td>FD</td>
<td>0.569</td>
<td>192.6</td>
<td>3,686</td>
<td>10,947</td>
<td>1005.2</td>
</tr>
<tr>
<td>AS</td>
<td>--</td>
<td>94.4</td>
<td>731</td>
<td>6,391</td>
<td>465.8</td>
</tr>
<tr>
<td>BC</td>
<td>0.350</td>
<td>118.5</td>
<td>3,699</td>
<td>10,947</td>
<td>1037.0</td>
</tr>
<tr>
<td>WA</td>
<td>0.313</td>
<td>105.9</td>
<td>2,414</td>
<td>10,947</td>
<td>606.4</td>
</tr>
<tr>
<td>HI</td>
<td>0.193</td>
<td>85.7</td>
<td>3,791</td>
<td>11,428</td>
<td>606.4</td>
</tr>
<tr>
<td>WP</td>
<td>1.250</td>
<td>453.5</td>
<td>731</td>
<td>6,381</td>
<td>650.3</td>
</tr>
<tr>
<td>BG</td>
<td>--</td>
<td>118.5</td>
<td>3,800</td>
<td>12,000</td>
<td>1037.0</td>
</tr>
<tr>
<td>UD</td>
<td>--</td>
<td>120.0</td>
<td>4,000</td>
<td>10,000</td>
<td>1000.0</td>
</tr>
</tbody>
</table>

aValues shown are largest values reported by Fowells (1965), increased arbitrarily by 25 percent, and then converted to metric units.

bAs suggested by Botkin et al. (1972), these values were calculated from maximum annual diameter-growth rates (this table) and maximum heights and diameters (Table 3) so that trees reach two thirds of maximum diameter at half their maximum age.

Values taken from Shugart and West (1977) except ST (assigned values of SM) and FB and AS (both assigned minimum values of RO and maximum values of WP, YB,-assigned minimum values of RO and maximum values of SM), and SB (assigned minimum values of Carya ovata and maximum values of SM). Values used for HI are the average of values for C. cordiformis, C. glabra, C. ovata, and C. tomentosa reported by Shugart and West (1972).

Sources: Monk et al. (1970), Pollard (1972), Rothacher et al. (1954), Whittaker et al. (1974), and Whittaker and Woodwell (1969) except RM and ST (assigned values of SM), PB and SB (YB), WA (HI), BW (AB), and WP (shortleaf pine).

Assumed using the seedling development data from Burns and Honkala (1990) where available; otherwise, assigned arbitrarily.

![Graph](image)

Figure 3.—Effect of superior leaf area (SLA) on available light (ALIGHT) reaching a particular tree crown.
For a given tree, available light (ALIGHT$_h$) and shade-tolerance class (ISHADE$_h$) determine the shading index (SHADE$_{h}$), which is used to modify diameter growth. By default, six tolerance classes are used: intolerant, intolerant-intermediate, tolerant-intermediate, tolerant, red maple, and red oak (Fig. 4). Red maple is assumed to behave like tolerant species at low light availability and like intolerant species at high light; red oak is assumed to behave like intolerant-intermediate species at low light availability and intolerant species at high light. The shade index is used as a diameter-growth multiplier.

![Graph showing the effect of available light on diameter growth by four tolerance classes: red oak and red maple have distinct light-effect characteristics.](image)

**Temperature**

The JABOWA model assumes that temperature affects growth rates by changing photosynthesis rates (Botkin et al. 1972). Each species is assumed to have an optimum temperature for photosynthesis, and with photosynthesis rates declining symmetrically above and below this optimum temperature. For each species, the minimum and maximum annual degree-days that occur within the species’ geographic range (default values shown in Table 4, from Botkin et al. 1972 and Shugart and West 1977) are used as the limits to photosynthesis and, therefore, growth. The temperature-growth modifier is calculated as:

$$DEGDT = ANNDD \times TFAC$$  \hspace{1cm} (11a)

$$TEMP_h = \frac{4.0 \times (DEGDT - COLD_h) \times (HOT_h - DEGDT)}{(HOT_h - COLD_h)^2}$$  \hspace{1cm} (11b)

where:

- $TEMP_h$ = temperature index for species $h$,
- $DEGDT$ = daily degree-days for trees (Equation 1) summed for the entire year,
- $TFAC$ = temperature effect adjustment factor (1.0),
- $COLD_h$ = minimum total degree-days per year that occur within the range of species $h$ (Table 4),
- $HOT_h$ = maximum total degree-days per year that occur within the range of species $h$ (Table 4).
The calculated value of TEMP, has been constrained arbitrarily to be at least 0.05. The relation between temperature index and annual degree-days is shown in Figure 5 using the maximum and minimum degree-day range for several species. TFAF is provided to allow uniform variation in heat accumulation across simulation years. Note that this is equivalent to changing both the daily temperatures and the threshold(s) by the same proportion.

![Graph showing the effect of total annual accumulated heat measured in degree-days, on temperature index for five tree species.](image)

Figure 5.- Effect of total annual accumulated heat measured in degree-days, on temperature index for five tree species.

**Crowding**

Diameter growth is assumed to decrease as relative stocking increases (Fig. 6):

\[
CROWD = 1.0 - (RSMULT \times RSTOCK)
\]

(12)

where:

- CROWD = crowding index,
- RSTOCK = relative stocking (Equation 8),
- RSMULT = crowding parameter (0.0025).

CROWD is further constrained by a lower limit (0.75), the value that CROWD reaches when RSTOCK reaches 100. Thus, overstocking has no additional effect. In the model, all trees in the stand are affected equally by crowding, regardless of species or diameter class.

**Defoliation**

Both current defoliation and defoliation history for the past 2 years are used to account for direct effects of defoliation on annual diameter growth. Percent defoliation for the previous 2 years is categorized as light (0 to 34 percent), medium (35 to 65 percent), or heavy (> 65 percent). The possible combinations of defoliation patterns have been assigned arbitrarily to
Figure 6.—Effect of relative stocking on stand density. As stocking increases, the stand density index (CROWD in equation 12) decreases to minimum of 0.75 at fully stocked.

one of two history categories, light or heavy (Table 7). Current defoliation is then used to determine the effect on diameter growth (when prior defoliation is light, use Equation 13; heavy, use Equation 14):

\[
DEFIND_{h,d} = 0.9689 - 0.00405 \times DEFOL_{h,s} \tag{13}
\]

\[
DEFIND_{h,d} = \frac{1.0}{1.3418 + 0.00540 \times DEFOL_{h,s}} \tag{14}
\]

where:

\[
DEFIND_{h,s} = \text{defoliation index for diameter class } d \text{ of species } h,
\]

\[
DEFOL_{h,s} = \text{percentage of foliage of species } h \text{ in the strata } s \text{ that corresponds to diameter class } d \text{ that has been destroyed by gypsy moth.}
\]

DEFOL_{h,s} is calculated by the gypsy moth model or supplied by the user. The parameters in Equations 13 and 14 were fit to data reported by Campbell and Garlo (1982) and Baker (1941) (Fig. 7).

Table 7.—Defoliation history categories used to calculate effect of defoliation* on annual diameter increment

<table>
<thead>
<tr>
<th>Defoliation history</th>
<th>Overall category</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 years ago</td>
<td>1 year ago</td>
</tr>
<tr>
<td>Light Light</td>
<td>Light</td>
</tr>
<tr>
<td>Light Medium</td>
<td>Light</td>
</tr>
<tr>
<td>Light Heavy</td>
<td>Heavy</td>
</tr>
<tr>
<td>Medium Light</td>
<td>Light</td>
</tr>
<tr>
<td>Medium Medium</td>
<td>Heavy</td>
</tr>
<tr>
<td>Medium Heavy</td>
<td>Heavy</td>
</tr>
<tr>
<td>Heavy Light</td>
<td>Heavy</td>
</tr>
<tr>
<td>Heavy Medium</td>
<td>Heavy</td>
</tr>
<tr>
<td>Heavy Heavy</td>
<td>Heavy</td>
</tr>
</tbody>
</table>

*Nonc = 0 percent; light = 1 to 30 percent; medium = 31 to 65 percent; heavy = 65+ percent.
Figure 7.—Effect of defoliation on diameter growth. Low (*) and high (O) previous defoliation were used to fit equations (13) and (14), respectively.

Predicted Diameter Growth

Annual diameter growth is calculated as a function of the base-growth amount and the four indices described. The base growth that would occur in the absence of crowding, shading, non-optimal temperatures, or defoliation is calculated as follows (from Botkin et al. 1972):

\[
GROWMX_{h,d} = \frac{GROWR_h \times DIAM_{d} \times \left[ 1.0 - \frac{DIAM_{d} \times HEIGHT_{h,d}}{DAX_{h} \times HMAX_{h}} \right]}{2.0 \times DBHHT + DIAM_{d} \times \left[ 3.0 \times B1_{d} - 4.0 \times B2_{d} \times DIAM_{d} \right]}
\]

where:

- \(GROWMX_{h,d}\) = maximum diameter growth (cm/year) that can be attained by a tree in diameter class \(d\) of species \(h\),
- \(GROWR_h\) = growth rate parameter for species \(h\),
- \(DIAM_{d}\) = mean d.b.h. (cm) for diameter class \(d\),
- \(HEIGHT_{h,d}\) = height (cm) of trees of species \(h\) in diameter class \(d\) (Equation 1),
- \(DBHHT\) = breast height (cm),
- \(DAX_{h}\) = maximum d.b.h. (cm) for species \(h\),
- \(HMAX_{h}\) = maximum height (cm) for species \(h\),
- \(B1_{d}\) and \(B2_{d}\) = height-growth coefficients for species \(h\).

Table 3 lists default values for \(DAX_{h}\), \(HMAX_{h}\), \(B1_{d}\), and \(B2_{d}\) while Table 4 lists those for \(GROWR_h\). Following Botkin et al. (1972), values for \(GROWR_h\) are set so that a tree that is half the maximum age will be two-thirds of the maximum diameter. Figure 8 shows the relation among diameter growth, maximum age, and maximum diameter. Negative calculated values of \(GROWMX_{h,d}\) are reset to zero.
Equation 16 is then used to predict annual diameter growth:

\[
GROW_{hd} = GROWMX_{hd} \times SHADE_{hd} \times TEMP_{h} \times CROWD \times DEFIND_{hd}
\]  

(16)

where:

- \(GROW_{hd}\) = actual diameter growth (cm/year) for trees of species \(h\) in diameter class \(d\),
- \(GROWMX_{hd}\) = maximum possible annual diameter growth for trees of species \(h\) in diameter class \(d\) (Equation 15),
- \(SHADE_{hd}\) = shading factor for diameter class \(d\) of species \(h\) (Fig. 9),
- \(TEMP_{h}\) = temperature index for species \(h\) (Equation 11),
- \(CROWD\) = crowding index for the stand (Equation 12),
- \(DEFIND_{hd}\) = defoliation index for diameter class \(d\) of species \(h\) (Equation 13 or 14, depending on defoliation history).

Figure 8.—Effect of current diameter and height on diameter increment. The abrupt increase as diameter increases (A) can be seen more clearly when diameter is presented in log scale (B). These graphs are for white oak (\(DMAX = 48\) inches; \(HMAX = 100\) feet \(= 3,050\) cm). For other species, similar graphs are scaled in proportion to \(DMAX\), \(HMAX\), and \(AGEMAX\).
Tree Mortality

The proportion of trees of a given diameter class and species that die each year is assumed to be a function of the base mortality rate and additional mortality that may occur during periods of reduced growth and/or defoliation.

Base Mortality Rates

The base or background mortality rate is calculated following Botkin et al. (1972). By assuming that base mortality rates are age-independent and that no more than 2 percent of saplings of a given species will reach the maximum age for that species, Botkin et al. estimated the probability that a tree will die in any given year:

$$BDIE_h = \frac{4.0}{AGEMAX_h}$$  \hspace{1cm} (17)

where:

- \(BDIE_h\) = background annual mortality rate for species \(h\),
- \(AGEMAX_h\) = maximum age (years) for species \(h\).

Default values used in the model for \(AGEMAX_h\) are shown in Table 3.

Mortality During Periods of Reduced Growth

Trees with annual diameter-growth rates that are less than a specified threshold (set to 0.05 cm/year by default) are assumed to be subject to additional mortality (following Botkin et al. 1972). Further, the probability of additional mortality is assumed to increase as the number of consecutive years with growth reduced below the threshold increases:

$$GDIE_{hd} = 1.0 - e^{SGMORT\times NSLOW_{hd}}$$  \hspace{1cm} (18)

where:

- \(GDIE_{hd}\) = additional proportion of trees of species \(h\) in diameter class \(d\) that will die in a given year,
- \(SGMORT\) = rate parameter for effect of slow growth on mortality (-0.64),
- \(NSLOW_{hd}\) = number of consecutive years of slow growth for species \(h\) in diameter class \(d\).

Figure 9 shows the relation between number of years with reduced growth (NSLOW) and additional mortality (GDIE). Diameter growth for each cell is compared to SLOWD; if less, NSLOW is incremented by 1.0. Otherwise, NSLOW is reset to zero. Users have access to both SLOWD, in the species-specific data-management screens and SGMORT as a standwise parameter, permitting local recalibrations.

Mortality During Periods of Defoliation

Defoliation of northeastern forests by gypsy moth often has been followed by increased tree mortality due to secondary agents, primarily Armillaria mellea, a root disease, or Agrilis bilineatus, the twolined chestnut borer, an insect (Baker 1941; Dunbar and Stephens 1976; Kegg 1971, 1973; Parker and Houston 1971; Wargo 1977). Reported mortality rates following gypsy moth defoliation (in percent) include 3 to 11 (Baker 1941), 1 to 50 (Brown et al. 1979), 25 to 84 (Campbell and Valentine 1972), 1 to 28 (Kegg 1971), 0 to 84 (Kegg 1973), and 0 to 42 (Stalter and Serrao 1983). Differences in tree species, stand species composition, duration and severity of outbreaks, length of observation periods, and other factors contribute to the variability in reported mortality rates. When other stresses such as drought or late frosts occur concurrently with defoliation, effects on trees may be exacerbated (Baker 1941; Crossman 1948; Nichols 1968; Stephens and Hill 1971). The effect of gypsy moth defoliation on tree mortality also is influenced by site and stand conditions (Kegg 1973; Stalter and Serrao 1983; Stephens 1971; Stephens and Hill 1971), and by individual-tree conditions (Campbell and Sloan 1977; Campbell and Valentine 1972; Gansner and Herick 1984).
The Stand-Damage Model uses defoliation as an indicator of subsequent mortality caused by gypsy moth. Additional mortality for a given species and diameter class following defoliation is assumed to be a function of the number of consecutive years of defoliation, soil-moisture category, and other stresses that may occur during the same year as the defoliation.

For years without other stress, the probability of mortality induced by gypsy moth defoliation is assumed to vary with the number of consecutive years of heavy defoliation ( > 65 percent) and soil-moisture category, as shown in Table 8. By default, all species are assumed to have the same probabilities of defoliation-induced mortality (given the same defoliation history and soil-moisture index), but these values are species specific and can be reset for any species (the table look-up function FDIE_{m,n} where h is the tree species, m is the site index, and n is the number of years of heavy defoliation). The tree mortality used at any specific instance (DDIE) is the current value of this function (FDIE). Note that mortality due to stresses is in addition to defoliation and is assumed to occur only for trees that are heavily defoliated ( > 65 percent).

Table 8.--Proportion of trees that die each year due to gypsy moth defoliation assuming no additional stress

<table>
<thead>
<tr>
<th>No. consecutive years with defoliation greater than 65%</th>
<th>Mesic</th>
<th>Intermediate</th>
<th>Xeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>3+</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
</tbody>
</table>
By default, no stress mortality will be scheduled (ISOPT = 0); users can choose either of two scheduling options. One selects the proportion of years that stress should occur (ISOPT = 1); the other allows the user to identify specific years when stress occurs (ISOPT = 2). For the former option, stress years will be scheduled at random such that the proportion of stress years matches the proportion selected by the user (STRESS, ) for the particular site moisture index (m). Users can alter the probability of high stress-induced mortality (STRFAC[2]) as well as mortality when stress is low (STRFAC[1]) but defoliation is heavy.

**Total Annual Mortality**

The annual mortality rate for a given species and diameter class is set to the sum of the mortality rates due to background mortality, reduced growth, defoliation, and additional stress:

\[
TDIE_{hd} = BDIE_h + GDIE_{hd} + DDIE_{h,m,n} + SDIE
\]  

(19)

where:

\[
TDIE_{hd} = \text{proportion of trees of species } h \text{ in diameter class } d \text{ that die at the end of the current year},
\]

\[
BDIE_h = \text{background annual mortality rate for species } h \text{ (Equation 17)},
\]

\[
GDIE_{hd} = \text{mortality induced by reduced growth for trees of species } h \text{ and diameter class } d \text{ (Equation 18)},
\]

\[
DDIE_{h,m,n} = \text{defoliation-induced mortality for species } h \text{ in a stand with soil-moisture index } m \text{ that has had defoliation greater than 65 percent for } n \text{ consecutive years (Table 8)},
\]

\[
SDIE = \text{additional mortality caused by other stresses in years with heavy defoliation (SDIE = STRFAC[ISTRES])}.
\]

By default, SDIE is set to 0.15 for years with high stress and 0.0 for low-stress years. For each species and diameter class, the number of live trees per ha (STEMS, ) is multiplied by the total annual mortality rate (TDIE, ) to determine the number of trees that will die during the current year. This number of dying trees is subtracted from the number of live trees at the end of each year.

**Applying Growth Calculations**

After mortality has been applied, the number of trees in each diameter class and species (STEMS, ) is adjusted to account for trees that grew from one diameter class to the next. For each species, all trees within any individual diameter class are assumed to be equally likely to grow into the next larger class. Each year, the number of trees that grow into the next diameter class is calculated as a function of the increase in diameter that year relative to the diameter range for that class:

\[
TREEN_{h,d} = \frac{GROW_{h,d}}{DLEN} \times STEMS_{h,d}
\]  

(20)

where:

\[
TREEN_{h,d} = \text{number of trees of species } h \text{ that will move from diameter class } d \text{ to diameter class } d+1 \text{ at the end of the current year},
\]

\[
GROW_{h,d} = \text{growth in diameter (cm/year) for species } h \text{ and diameter class } d \text{ (Equation 16)},
\]

\[
DLEN = \text{width (cm) of diameter classes},
\]

\[
STEMS_{h,d} = \text{number of stems of species } h \text{ in diameter class } d \text{ at the start of the year}.
\]

Beginning with the second largest diameter class and continuing to the smallest, the number of trees growing into the next larger diameter class is calculated using Equation 20; this number is added to the number of stems in the next larger diameter class and subtracted from the original diameter class.
Stem Recruitment

The net effects of seedling establishment and early regeneration growth are simulated by calculating the number of stems that are recruited each year to the smallest diameter class of each tree species, that is, trees entering the first diameter class have an associated d.b.h. The Stand-Damage Model assumes that for each species there is a maximum number of new stems that can be added per year (see Table 6 for default values). Under this assumption, seedling establishment (seed generation, viability, and germination) and growth of trees until they have reached the diameter of the smallest class (class midpoint), are not modeled explicitly. Rather, only the number of stems entering that smallest class is simulated.

The maximum possible stem recruitment is adjusted to account for shading and random variation. Relative stocking (Equation 8) is used to determine the effect of shading on recruitment for five shade-tolerance classes. Figure 10 shows the relationships between relative stocking and recruitment that are used by default. Red maple, assigned to the fifth tolerance class, is assumed to behave like intolerant species at low stocking levels and tolerant species at high stocking levels. Random variation is simulated by selecting a number from a uniform distribution between 0 and 1 (inclusive) and using that number to further adjust the number of stems recruited:

\[
\text{NEWST}_h = \text{RECRUT}_h \times \text{RSHADE}_h \times \text{RANDRC}_h
\]

where:

- \(\text{NEWST}_h\) = number of new stems recruited to the smallest diameter class for host \(h\),
- \(\text{RECRUT}_h\) = maximum number of stems that can be recruited in 1 year,
- \(\text{RSHADE}_h\) = index for the effect of relative stand density as measured by RSTOCK (Equation 8) on stem recruitment for host \(h\) (Fig. 12),
- \(\text{RANDRC}_h\) = random number from a uniform distribution between 0 and 1 that has been selected for host \(h\).

![Graph showing effect of relative stocking (RSTOCK) on maximum recruitment (RSHADE). As stocking increases, recruitment decreases for four tolerance classes except that red maple is intolerant at high light and tolerant at low light.](image.png)

Figure 10.--Effect of relative stocking (RSTOCK) on maximum recruitment (RSHADE). As stocking increases, recruitment decreases for four tolerance classes except that red maple is intolerant at high light and tolerant at low light.
Users can alter the piecewise linear relationship between stocking level, RSTOCK, and shading, RSHADE. There are four shade-tolerance classes to which species are assigned. Red maple has been assigned separately to the fifth class, because it behaves like tolerant species at low stocking levels and intolerant species at high stocking levels.

Output

Output is produced in tabular formats and in ASCII files is suitable for statistical or graphics software packages. Users determine which files are created and which are permanently archived to disk. For each species and crown class (overstory or understory), the stand table summarizes basal area, number of stems, volume, average diameter, total foliage biomass, diameter growth, growth modifiers, tree mortality, and sources of mortality. The stand table can be printed at intervals selected by the user (such as every 5 years) or for specific years. An example of the stand table output is shown on pages 23 and 24 as Figure 11.

Users control ASCII files content, which can represent only overstory trees, understory trees, or both understory and overstory trees by species. Separate files are produced for basal area, number of stems, tree volume, and average (quadratic mean) diameter. In Figures 12-15, using the example stand, ASCII files have been plotted in a format similar to that produced by the model software. The format of each of these files is described in detail in the User's Guide (Colbert and Racin 1994) and in the on-line help system under the output selection windows.
### User supplied input/output information

**Input Data File Name:** EXAMPLE.IPF
**User Name:** Paynt & Fitch brook
**Job Name:** Block 41 Stand 123
**Site Number:** 711, 714 PA, USA

**Date:** September 2, 1978

---

#### User notes supplied through the Setup-Edit Job Description

- **Stand Output Table:** EXAMPLE.TAB, printed every other year.
- **Other outputs:** printed every year for all trees (category 1), stem count, basal area, & volume; these output files not saved.
- **Parameter changes:** Sample plot area = 0.3 AC., stand area = 2.4 AC.
- **Duration:** 1978. **Duration:** 10 years.
- **Sampled basal area:** Approximately 65% oak and 35% red maple.
- **Defoliation years:** 1981, 1986

### Damage Model Version 1.1: Parameter Values

| No. of Years to be Simulated: 13 | Standard Plot Area: 1.4 AC | Random Number State: 2633
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output to be produced every 2 Years</td>
<td>Total Sample Plot Area: 3 AC</td>
<td>Add. Tree Mort. due to Stress: 3745</td>
</tr>
<tr>
<td>Site moisture index: 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Defoliation data will be read from file:** DEFOLDAT.DIS

#### Overview / Understory Boundary (Based on Diameter)

- **Minimum Diameter:** 5.00 (IN)

#### Shading Parameters

- **Height:** 1.0
- **Tree Density:** 0.06
- **Plot Size for Shading:** 0.20 AC

#### Effect of Averaged Height on Diameter Growth, by Tolerance Classes (PROP, AVAIL, LIGHT, PROP. OF POT. GROWTH):

<table>
<thead>
<tr>
<th>Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>1.0</td>
<td>0.7</td>
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<td>0.2</td>
</tr>
<tr>
<td>1.1</td>
<td>0.8</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>1.2</td>
<td>0.9</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>1.3</td>
<td>1.0</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

#### Multiplier for Effect of Relative Diameter on Diameter Growth:

- **0.025**

#### Effect of Relative Stochastic on Recruitement, by Tolerance Classes (REL, STOCKING, PROP. OF POT. RECRUIT):**

<table>
<thead>
<tr>
<th>Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>1.0</td>
<td>0.7</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>1.1</td>
<td>0.8</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>1.2</td>
<td>0.9</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>1.3</td>
<td>1.0</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>

No additional stress included (ISMO = 0).

#### Additional Mortality in Years with No Stress: 0.00, IN YEARS WITH STRESS: 0.15

- **0.2**

#### Parameters that Vary with Tree Species:

<table>
<thead>
<tr>
<th>Species Code</th>
<th>RM</th>
<th>NO</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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</tr>
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<td>2</td>
<td>2</td>
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</tr>
<tr>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

#### Relative Storcking Class

- **2**

#### Recruitment Tolerance Class

- **5**

#### Diameter Growth Parameters

- **50.0**

#### Maximum Height (FT)

- **70.0**

#### Maximum Age (Years)

- **250.0**

#### Minimum Annual Day Degree

- **1800.0**

#### Maximum Annual Day Degree

- **2000.0**

#### Diameter Growth Parameter

- **194.4**

#### Height Parameter B1

- **65.51**

#### Height Parameter B2

- **53.73**

#### Pollage Biomass Parameter P1

- **0.0082**

#### Pollage Biomass Parameter P2

- **2.0150**

#### Surface Area: Biomass Ratio

- **205.0**

#### Max. Annual Tree Recruitment

- **50.0**

#### Male Breeding Sites / Sq. Ft.

- **0.092**

#### Crown Rotation Sites / Sq. Ft.

- **0.615**

#### Live Crown Ratio Parameters

- **4.35**

#### Add. Mort. when Growth Slow

- **0.10**

#### Base mortality rate

- **0.0000**

#### Tree Mortality Rates Following Heavy Defoliation:

**YEARS OF HEAVY DEPOL.**

<table>
<thead>
<tr>
<th>Species</th>
<th>RM</th>
<th>NO</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>3</td>
<td>0.1</td>
<td>0.1</td>
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</tr>
</tbody>
</table>

No Stand Treatments Scheduled

### Damage Model Version 1.1: Initial Conditions

#### Number of Stems Per AC:

<table>
<thead>
<tr>
<th>Species</th>
<th>1.0</th>
<th>3.0</th>
<th>5.0</th>
<th>7.0</th>
<th>9.0</th>
<th>11.0</th>
<th>13.0</th>
<th>15.0</th>
<th>17.0</th>
<th>19.0</th>
<th>21.0</th>
<th>23.0</th>
<th>25.0</th>
<th>27.0</th>
<th>29.0</th>
<th>31.0</th>
<th>33.0</th>
<th>35.0</th>
<th>37.0</th>
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<tbody>
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<td>.00</td>
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</tbody>
</table>

#### Defoliation History:

<table>
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<tr>
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</thead>
<tbody>
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<td>0</td>
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</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

24
### SOURCES OF MORTALITY

**MODIFIERS OF GROWTH**

<table>
<thead>
<tr>
<th>Spec Strat</th>
<th>Depol Area</th>
<th>Stem DBH</th>
<th>Volumes</th>
<th>Yield</th>
<th>Pulp Age</th>
<th>Growth</th>
<th>Girth</th>
<th>Temp</th>
<th>Dens</th>
<th>Share Mort</th>
<th>MORT. MORT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO OVER</td>
<td>0.4 23.8 1.9 2.1</td>
<td>0.439 0.811 134 1 000</td>
<td>0.868</td>
<td>0.891</td>
<td>1.6</td>
<td>1.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**End of Year: 1980**

**Accumulated day-degrees for: 4570.0**

<table>
<thead>
<tr>
<th>Spec Strat</th>
<th>Depol Area</th>
<th>Stem DBH</th>
<th>Volumes</th>
<th>Yield</th>
<th>Pulp Age</th>
<th>Growth</th>
<th>Girth</th>
<th>Temp</th>
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<td>1.6</td>
<td>1.6</td>
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</tbody>
</table>

**End of Year: 1982**

**Accumulated day-degrees for: 4570.0**

<table>
<thead>
<tr>
<th>Spec Strat</th>
<th>Depol Area</th>
<th>Stem DBH</th>
<th>Volumes</th>
<th>Yield</th>
<th>Pulp Age</th>
<th>Growth</th>
<th>Girth</th>
<th>Temp</th>
<th>Dens</th>
<th>Share Mort</th>
<th>MORT. MORT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO OVER</td>
<td>0.4 23.8 1.9 2.1</td>
<td>0.439 0.811 134 1 000</td>
<td>0.868</td>
<td>0.891</td>
<td>1.6</td>
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</tbody>
</table>

**End of Year: 1984**

**Accumulated day-degrees for: 4570.0**

<table>
<thead>
<tr>
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<th>Depol Area</th>
<th>Stem DBH</th>
<th>Volumes</th>
<th>Yield</th>
<th>Pulp Age</th>
<th>Growth</th>
<th>Girth</th>
<th>Temp</th>
<th>Dens</th>
<th>Share Mort</th>
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</thead>
<tbody>
<tr>
<td>CO OVER</td>
<td>0.4 23.8 1.9 2.1</td>
<td>0.439 0.811 134 1 000</td>
<td>0.868</td>
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**End of Year: 1986**

**Accumulated day-degrees for: 4570.0**

<table>
<thead>
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<th>Spec Strat</th>
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<th>Stem DBH</th>
<th>Volumes</th>
<th>Yield</th>
<th>Pulp Age</th>
<th>Growth</th>
<th>Girth</th>
<th>Temp</th>
<th>Dens</th>
<th>Share Mort</th>
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</thead>
<tbody>
<tr>
<td>CO OVER</td>
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<td>0.868</td>
<td>0.891</td>
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</table>

**End of Year: 1988**

**Accumulated day-degrees for: 4570.0**

<table>
<thead>
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<th>Volumes</th>
<th>Yield</th>
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<th>Girth</th>
<th>Temp</th>
<th>Dens</th>
<th>Share Mort</th>
<th>MORT. MORT.</th>
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<tbody>
<tr>
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<td>0.868</td>
<td>0.891</td>
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</tr>
</tbody>
</table>

**End of Year: 1990**

**Accumulated day-degrees for: 4570.0**

<table>
<thead>
<tr>
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<th>Stem DBH</th>
<th>Volumes</th>
<th>Yield</th>
<th>Pulp Age</th>
<th>Growth</th>
<th>Girth</th>
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<th>Dens</th>
<th>Share Mort</th>
<th>MORT. MORT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO OVER</td>
<td>0.4 23.8 1.9 2.1</td>
<td>0.439 0.811 134 1 000</td>
<td>0.868</td>
<td>0.891</td>
<td>1.6</td>
<td>1.6</td>
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</tr>
</tbody>
</table>

**NUMBER OF STEMS PER AC**

| Species | 1.0 | 3.0 | 5.0 | 7.0 | 9.0 | 11.0 | 13.0 | 15.0 | 17.0 | 19.0 | 21.0 | 23.0 | 25.0 | 27.0 | 29.0 | 31.0 | 33.0 | 35.0 | 37.0 | 39.0 |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| RM 056 334 44 | 312 | 272 | 235 | 198 | 161 | 124 | 87  | 50 | 13 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |
| DM 54.62 35.98 | 125 | 92 | 61 | 30 | 15 | 7 | 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CO 73.48 33.31 | 41 | 12 | 8 | 4 | 2 | 1 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Figure 11.- Output table generated by the model: this copy was generated using the file EXAMPLE.INP that is bundled as part of the installation package.

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Figure 12.—Number of stems of each species over time (all trees) using the example stand. The user can select output for all trees, only overstory trees, or only understory trees.

Figure 13.—Basal area over time (all trees) using the example stand. If the user changes units from English to metric, the output graphs are rescaled automatically and the axis labels are reset accordingly.
Figure 14. Stand volume by species over time (all trees) using the example stand.

Figure 15.—Quadratic mean diameter by species over time (all trees) using the example stand.
Acknowledgments

We gratefully acknowledge the assistance of Angela Mann in formatting the documentation and providing technical support in code documentation and format revisions. We thank Dr. Xu Rumei, Department of Biology, Beijing Normal University, for his review and assistance in code development, and Dr. Alexei Sharov, visiting scientist with the Department of Mathematics of West Virginia University, for his review of the model user interface. We also thank Richard L. Ernst, Mike Foster, Kevin W. Thorpe, and Ralph E. Webb for their review of an earlier draft of this manuscript. Special thanks go to Nicholas Croustok of the USDA Forest Service, Intermountain Research Station, Moscow, Idaho, for his constructive review of this document and the associated publications and code. Finally, we thank Mark Twery, Andrew Liebhold, and Kurt Gottschalk for their continuing review of the model as it was being developed, and David Feucht and Sandra Fosbroke for their reviews and assistance in obtaining example and test data.

Literature Cited


### Appendix A
Structure of the Stand-Damage Model Code: Call Sequencing

Parenthetic listings are line numbers of the calls within the routine at the prior level.

<table>
<thead>
<tr>
<th>Damage (Main)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>INITW (L229)</td>
<td>PRIOTE (L260)</td>
</tr>
<tr>
<td>TINIT (L231)</td>
<td>PTSTBL (L406)</td>
</tr>
<tr>
<td>PINIT (L232)</td>
<td></td>
</tr>
<tr>
<td>THGHTS (L234)</td>
<td>GTCRWD (L218)</td>
</tr>
<tr>
<td>start primary</td>
<td>RANDS (L234)</td>
</tr>
<tr>
<td>loop -- years</td>
<td>PTSTBL (L516)</td>
</tr>
<tr>
<td>TREE1 (L262)</td>
<td>SLIP (L336)</td>
</tr>
<tr>
<td>RELSTK (L266)</td>
<td>PTSTBL (L534)</td>
</tr>
<tr>
<td>PLUPDT (L271)</td>
<td>RANXS (L535)</td>
</tr>
<tr>
<td>DTRGOL (L205)</td>
<td>PTSTBL (L543)</td>
</tr>
<tr>
<td>TREE21 (L298)</td>
<td></td>
</tr>
<tr>
<td>TREE22 (L299)</td>
<td></td>
</tr>
<tr>
<td>WASCTII (L300)</td>
<td></td>
</tr>
<tr>
<td>GNXTIMG (L301)</td>
<td></td>
</tr>
<tr>
<td>TPRINT (L307)</td>
<td></td>
</tr>
<tr>
<td>TPRINT (L311)</td>
<td></td>
</tr>
<tr>
<td>end primary</td>
<td>SLIP (L316)</td>
</tr>
<tr>
<td>loop -- years</td>
<td></td>
</tr>
<tr>
<td>PTSTBL (L329)</td>
<td></td>
</tr>
<tr>
<td>CLEAN (L333)</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix B Description of Stand-Damage Model Routines

<table>
<thead>
<tr>
<th>Routine</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLOCK DATA</td>
<td>Describes fixed values used for common block parameters.</td>
</tr>
<tr>
<td>CLEAN</td>
<td>The cleanup routine that closes all disk files.</td>
</tr>
<tr>
<td>DAMAGE</td>
<td>Main routine that controls the Stand-Damage Model; after initializing and setting up the system, it runs through the main loop once for each year to be simulated; then it does the final writing of summary data and cleanup before returning control to the user interface.</td>
</tr>
<tr>
<td>DEFOL</td>
<td>Used with the Stand-Damage Model to read defoliation estimates provided by the user and uses those rates to adjust the amounts of foliage present. This routine is not used when the stand model is linked to the gypsy moth model.</td>
</tr>
<tr>
<td>FLUPDT</td>
<td>This subroutine calculates the function that accounts for the effects of last year's defoliation on this year's foliage production. ( DFY = \text{percent defoliation last year} ).</td>
</tr>
<tr>
<td>GNXTMG</td>
<td>This section brings in the next management year and action type.</td>
</tr>
<tr>
<td>GTCRWD</td>
<td>Calculates the stand competition factor (&quot;CROWD) as a function of the relative stocking index (\text{HISTOCK}) and (\text{RSMULT}) (set arbitrarily). (\text{CROWD}) is constrained and has a minimum value of 0.75, the user-accessible value of the parameter (\text{CRWDMN}).</td>
</tr>
<tr>
<td>INITW</td>
<td>Reads parameter values and initial conditions from file with handle (\text{JWIN}).</td>
</tr>
<tr>
<td>PINIT</td>
<td>Writes (prints) parameter values and initial conditions for the stand model.</td>
</tr>
<tr>
<td>PRNOTE</td>
<td>Produces copy of user's input notes as part of output table header information; writes them to Stand Table file.</td>
</tr>
<tr>
<td>PRTMGT</td>
<td>Writes stand management treatments that have been scheduled to Stand Table file.</td>
</tr>
<tr>
<td>PTSTBL</td>
<td>Writes (\text{Print}) the Stand Table (\text{stem counts by species and diameter class}).</td>
</tr>
<tr>
<td>RANDS</td>
<td>Pseudo-random number generator.</td>
</tr>
<tr>
<td>RELSTK</td>
<td>Calculates relative stocking (\text{RSTOCK}) based on \text{SILVAH} (Marquis et al. 1992); sums total number of stems by diameter class in three stocking groups identified in \text{SILVAH} as (\text{TOT1, TOT2, and TOT3}).</td>
</tr>
<tr>
<td>SLIP</td>
<td>Linear-interpolation function. Input is XX; find YY(XX) by linear interpolation; ((X(I), Y(I))) pairs are used for XX greater than (X(1)) and less than (X(N)); otherwise, end value (Y(1)) or (Y(N)) is used.</td>
</tr>
<tr>
<td>THGHTS</td>
<td>Calculates heights (cm) for each host-diameter class (\text{HEIGHT}). See Equation 2. If the diameter is greater than the maximum diameter for species (\text{ih}), sets height equal to maximum height for species (\text{ih}).</td>
</tr>
<tr>
<td>TINIT</td>
<td>Reads parameter values and initial conditions for stand model.</td>
</tr>
<tr>
<td>TPRINT</td>
<td>Writes Stand Table Output summary for 1 year.</td>
</tr>
<tr>
<td>TREE1</td>
<td>Calculates foliage amounts, crown ratios, number of resting sites, and stem counts and basal area in the under and overstory strata by tree species. Called from the main program \text{DAMAGE} or \text{DAMSR}. No calls are made by this routine.</td>
</tr>
<tr>
<td>TREE21</td>
<td>This routine (1) calculates superior leaf area for each tree class, (2) sets crowding factor for this year, (3) sets stress option \text{ISTRES} for this year, (4) reads management prescription data for this year (if any), and (5) sets up \text{DEBUG} output printing.</td>
</tr>
</tbody>
</table>
Calculates diameter-growth and mortality rates for each tree species and diameter class, followed by recruitment of new stems and management entries. First the temperature modifier of growth is calculated for each species; then for each diameter class and host, the defoliation modifier, shading modifier, and potential and actual growth are calculated. Then the mortality factors are calculated and accumulated (past and current defoliation, stress, slow growth, and background rates). Growth and mortality effects are summarized for tabular and ASCII file output. Growth is simulated by moving stem counts between diameter classes. Management entries (tree removals) are simulated followed by further summarizing of the stand for output. Finally, defoliation histories (by tree species and crown strata) for the year are updated.

WASCII

Writes output data as flat ASCII formatted files to disk for use in plotting or permanent archiving for other uses. There are four separate files, one each for stem counts, basal area, volume, and quadratic mean diameter by species for specified strata (overstory trees only, understory trees only, or all trees).
## Appendix C  Code Listings

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Routine Name</th>
<th>Source Code File Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>BLOCK DATA</td>
<td>BLKDATA.FOR</td>
</tr>
<tr>
<td>C2</td>
<td>CLEAN (IOPT)</td>
<td>CLEANUP.FOR</td>
</tr>
<tr>
<td>C3</td>
<td>DAMAGE</td>
<td>DAMSR.FOR</td>
</tr>
<tr>
<td>C4</td>
<td>DEFOL</td>
<td>DEFOL.FOR</td>
</tr>
<tr>
<td>C5</td>
<td>FLUPDT</td>
<td>FOLUPDTE.FOR</td>
</tr>
<tr>
<td>C6</td>
<td>GNXTMG</td>
<td>GETNXTMG.FOR</td>
</tr>
<tr>
<td>C7</td>
<td>GTCRWD</td>
<td>GETCROWD.FOR</td>
</tr>
<tr>
<td>C8</td>
<td>INITW</td>
<td>INITW.FOR</td>
</tr>
<tr>
<td>C9</td>
<td>PINIT</td>
<td>PINIT.FOR</td>
</tr>
<tr>
<td>C10</td>
<td>PRNOTE</td>
<td>PRNOTE.FOR</td>
</tr>
<tr>
<td>C11</td>
<td>PRTMGMT</td>
<td>PRNTMGMT.FOR</td>
</tr>
<tr>
<td>C12</td>
<td>PTSTBLE</td>
<td>PRNSTBL.FOR</td>
</tr>
<tr>
<td>C13</td>
<td>RANDS (K, YFLO)</td>
<td>RANDS.FOR</td>
</tr>
<tr>
<td>C14</td>
<td>RELSTK</td>
<td>RELSTOCK.FOR</td>
</tr>
<tr>
<td>C15</td>
<td>SLIP (XX, X, Y, N)</td>
<td>SLIP.FOR</td>
</tr>
<tr>
<td>C16</td>
<td>THGHTS</td>
<td>THEIGHTS.FOR</td>
</tr>
<tr>
<td>C17</td>
<td>TINIT</td>
<td>TINIT.FOR</td>
</tr>
<tr>
<td>C18</td>
<td>TPRINT</td>
<td>TPRINT.FOR</td>
</tr>
<tr>
<td>C19</td>
<td>TREE1</td>
<td>TREE1.FOR</td>
</tr>
<tr>
<td>C20</td>
<td>TREE21</td>
<td>TREE21.FOR</td>
</tr>
<tr>
<td>C21</td>
<td>TREE22</td>
<td>TREE22.FOR</td>
</tr>
<tr>
<td>C22</td>
<td>WASCII</td>
<td>WRITASCII.FOR</td>
</tr>
</tbody>
</table>
c ***** BLOCK DATA, file: BLKDATA.FOR *****

A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model (the stand
submodel) converted to a stand-alone model. Last revised by K.Sheehan January
1988; revised starting in 1989 by Colbert and Racin.

J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

** Local variables, parameters, and inputs required by BLKDATA.FOR **
The following designations for LOCATIONS apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) -XXN := CAPS or CAPS+digit indicate a common block name

NAME - LOCATION - DESCRIPTION
-----------------------------------------------
NDIAM S4 - Number of diameter classes to be simulated
STRATA CHAR1 - The 4 strata names to be simulated for each host

BLOCK DATA

**** Include common blocks ****

INCLUDE 'CHAR1.CMB'
INCLUDE 'S4.CMB'

DATA STRATA / 'OVER', 'UNDER', 'SHRUB', 'BOLE' /
DATA NDIAM / 20 /

END
**** Subroutine CLEAN, file: CLEANUP.FOR *****

A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
revised by K. Sheehan January 1988; revised starting in 1989
by Colbert and Racim.
J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

Called from main program DAMGR.
No subroutines are called by this routine.

** Local variables, parameters, and inputs required
by Subroutine CLEAN(IOPT) **
The following designations for LOCATIONs apply:
(1) - i := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) -XXN:= CAPS or CAPS+digit indicate a common block name

NAME = LOCATION - DESCRIPTION
-----------------------------------------------
DEBUG LOG1 - Logical variable, true to produce Debug output
IOPT cp - Means to pass ISOPT, Stress option indicating
d additional tree stress has been designated in
specific years.
LDEPOL LOG2 - Logical variable, true if defoliation data is
to be obtained from external file.
STABLE LOG2 - Logical variable, true to produce tabular output.
TGBA LOG2 - Logical variable, true to produce ASCII data file
of basal area by species each year.
TDBH LOG2 - Logical variable, true to produce ASCII data file
of mean DBH for each species each year.
TGSTEM LOG2 - Logical variable, true to produce ASCII data file
of total stem count for each species each year.
TGVOL LOG2 - Logical variable, true to produce ASCII data file
of total stem volume across each species each year.

SUBROUTINE CLEAN (IOPT)

**** Include common blocks ****

INCLUDE 'LOG1.CMB'
INCLUDE 'LOG2.CMB'

CLOSE (9)
CLOSE (10)
CLOSE (20)
IF (IOPT .EQ. 2) CLOSE (11)
IF (DEBUG) CLOSE (12)
+-IF (STABLE) THEN
| ENDFILE (UNIT = 13)
| REWIND (13)
56 | CLOSE (13)
57 | +--ENDIF
58 | IF (LDEFO) CLOSE (14)
59 | IF (TSTEM) CLOSE (15)
60 | IF (TGBA) CLOSE (16)
61 | IF (TGDB) CLOSE (17)
62 | IF (TGDBH) CLOSE (18)
63 | c end of cleanup operations...
64 | RETURN
65 | END
66 | c *** End of subroutine CLEAN; file name CLEANUP.FOR ***
INTERFACE TO INTEGER*2 FUNCTION PDAUGAE(C)(IY)
INTEGER IY
END

***** Main Program, called from the c interface code,
as the subroutine, DAMAGE, file: DAMSR.FOR *****
A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
revised by K.Sheehan January 1988; revised starting in 1989
by Culbert and Racin.

J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

Called by the user interface (C-code).
Calls made to: DEPOL, FLUPDT, GNXTMG, PINIT, PTSTBL, RELSTK, THGHTS,
TINIT, TREE1, TREE21, TREE22, and WASCII.
** Local variables, parameters, and inputs required
by Subroutine DAMSR() **
or by Main Program DAMAGE. **
The following designations for LOCATIONS apply:

(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) -XXN:= CAPS or CAPS+digit indicate a common block name

NAME - LOCATION - DESCRIPTION
---------------------------------------------------------------------
DEBUG LOG1 - True if debug output is desired
FOL S
FLUPDT S
FOL S3 - Potential foliage biomass (g/ha) by host & strata.
GMSUBM 1 - True if gypsy moth submodel is to be used; included
for compatibility when linked to gypsy moth model.
GNXTMG S - Used in system call to clear screen
IGYEAR S4 - Index for printing graphic output to files. KGYEAR,
initialized to 0, is incremented in the main (DO 20)
IH L - Host species index
INITW S
IYEAR GEN1 - Output interval for stand submodel (Stand table); if
set to 0, then print output in years listed in
IVIEW(iy)
IS L - Strata index
ISEED(i) GEN1 - Seeds for random number generator (1=establishment
of new trees, 2= not used at this time, 3=additional
tree mortality due to stress, 4=additional gypsy
moth mort. due to winter temperatures, 5 = weather
data generation, 6 = gypsy moth L1 dispersal.
ISOPT S4 - Tree species option: 1= stress occurs in random yrs
2= user specifies stress yrs
56 c ISYEAR  GEN1 - Initially, calendar year to start simulation; then
57 c    calendar year counter during simulation.
58 c IVIEW(iy) S4 - Years that stand submodel output is desired; used
59 c only if IPYEAR = 0
60 c IFORM  GEN1 - Format # for weather data
61 c IWOPT  GEN1 - Weather option: 1 = 1 year, 2 = more than 1 year, 3 =
62 c    generate weather data, 4 = use annual degree-days
63 c IYEAR  GEN1 - Current year of simulation
64 c JDB    GEN1 - DEBUG output file handle.
65 c JGEN   GEN1 - General data file (always req.; sets no. of
66 c    years to be simulated, etc.)
67 c JTIN   GEN1 - Tree data file (req. if stand submodel is used)
68 c JWIN   GEN1 - Weather data file (always req.) - annual degree-day
69 c    totals. For the stand model only!
70 c KGYEAR S4 - Counter for number of years since last writing of
71 c    ASCII data for file(s)
72 c KYEAR  1 - No. of yrs since output was last printed
73 c LDEPOL LOG2 - True if defoliation to be simulated
74 c LRAIN  LOG1 - True if user wants to use rain data (may slow
75 c    development of larvae.)
76 c MV     1 - Index for IVIEW
77 c NHOSTS GEN1 - Number of host tree species
78 c N_LINES GEN1 - Number of lines of text in the user notes file.
79 c    for printing as part of the tabular output.
80 c NUMLIN GEN1 - Line counter for tabular output.
81 c NWAYR  GEN1 - Number of years of weather data
82 c NYEARS GEN1 - Number of years simulation is to run
83 c OVERBA S3 - Overstory basal area, by host
84 c OVERS  S3 - Overstory number of stems, by host
85 c PGAUGE s - Call to C-function to run the pop-gauge during
86 c    the simulation, the current year counter is passed.
87 c PINIT  s
88 c PTSTBL s
89 c RELSTK s
90 c RNSCn, CHAR1 - Five lines, each is a 20 character string passed to
91 c    the model for inclusion as banner information in the
92 c RNSCS S3 - Number of resting sites, by host and strata
93 c STABLE LOG2 - True if stand table output is desired
94 c STSNUM GEN1 - True if stand submodel is to be used
95 c TEMPC LOG2 - True if temps are metric
96 c TFAC  WTHR1 - Temperature multiplier
97 c TGBA LOG3 - True if ASCII output files (basal area) are to be
98 c    produced.
99 c TGDBH LOG2 - True if ASCII output files (mean d.b.h.) are to be
100 c    produced.
101 c TGSTEM LOG2 - True if ASCII output files (no. stems) are to be
102 c    produced.
103 c TGVOL LOG2 - True if ASCII output files (volume) are to be
104 c    produced.
105 c THGHTS s
106 c TINIT  s
107 c TNAME{ih}CHAR1 - 2 Char. code for tree species.
108 c TPRINT s
109 c TREE1 s
110 c
11-17-94 11:25:06 DAMSR.FOR
Thu 11-17-94 11:27:21 DAMAGE

111 c TREE21 s
112 c TREE22 s
113 c TETHR WTHR - Lower threshold for trees (used in stand submodel only).
115 c UNDBA S1 - Understory basal area, by host
116 c UNDERS S3 - Understory number of stems, by host
117 c WASCII s
c

SUBROUTINE DAMAGE

122 10010 FORMAT (IX, I2, 1X, I2)
123 10020 FORMAT (IX, L1, 1X, L1, 1X, L1)
124 10030 FORMAT (' YOU ARE TRYING TO RUN THE DAMAGE MODEL EITHER', /
125 * ' WITHOUT THE STAND SUBMODEL OR WITH THE GM SUBMODEL.', /
126 * ' PLEASE CHECK THE GENDATA.X FILE')
127 10040 FORMAT (IX, I3, 1X, I4/2(IX, I2, 1X, L1), 3(IX, L1)/, 2(10(IX,
128 * 13)/6(IX, I7))
129 10050 FORMAT (IX, F5.2, 1X, I3, 1X, F6.2, 2(1X, I1), 2(1X, L1))
130 10060 FORMAT (' The stand model will not use rain data,')
131 10070 FORMAT (' MAIN 3006: TINIT DONE ')
132 10090 FORMAT (' MAIN 3040: TREE1 DONE ')
133 10100 FORMAT (' MAIN 3042: ', 2F8.2)
134 10110 FORMAT (' DATA: OVERBA(IH),UNDBA(IH),FOL(TH,1),',
135 * 'FOL(IN,2),(RESNHS(IH,IS),IS=1,4),/2F9.0,2F11.0/4F6.0)
136 10120 FORMAT (' MAIN 3060: DEFOILATION DONE ')
137 10130 FORMAT (' MAIN 3070: TREE2x, WASCII, and GNXTMG done.')
138 10140 FORMAT (IX, I2, 12(1X,A2))

139 c *** INCLUDE common blocks... ***

140 INCLUDE 'CHARL.CMB'
141 INCLUDE 'CEN1.CMB'
142 INCLUDE 'LOG1.CMB'
143 INCLUDE 'LOG2.CMB'
144 INCLUDE 'S2.CMB'
145 INCLUDE 'S3.CMB'
146 INCLUDE 'S4.CMB'
147 INCLUDE 'WTHR2.CMB'

148 c *** End of Common blocks ***

149 LOGICAL STSUBM, GMSUBM

150 c Clear the screen for the start of simulation.
151 INTEGER*2 PGUAGE

152 c Set the page length counter for initial page eject and line banner in
153 c TPRINT routine.
154 NUMLIN = 80

155 c Open the general data file: GENDATA.
OPEN (9, FILE = 'GENDATA.D1S', STATUS = 'OLD')
JGEN = 9

! Read general information
READ (JGEN, 10010) NHOSTS, NLINES
READ (JGEN, '(A)') RNPC1, RNPC2, RNPC3, RNPC4, RNPC5
READ (JGEN, 10020) STSUBM, GMSUBM, DEBUG

! Open the stand data file: treedata.
IF (STSUBM) OPEN (10, FILE = 'TREEDATA.D1S', STATUS = 'OLD')
JTIN = 10

! --IF (.NOT. STSUBM .OR. GMSUBM) THEN
    WRITE (*, 10030)
    STOP
! --ELSE

    IF (DEBUG) OPEN (12, FILE = 'DEBUGDAMG.D1S', STATUS = 'UNKNOWN')
    JDB = 12
    READ (JGEN, 10040) NYEARS, ISYEAR, IPYEAR, STABLE, IGYEAR,
    *           TSTEM, TGBA, TVOL, TDEH, (IVIEW(I), I = 1, 20),
    *       (ISERD(I), I = 1, 6)
    INITYR = ISYEAR

! --> Read weather info. <---
READ (JGEN, 10050) TFAC, NAMPAK, TRETHK, IWFURM, IWOPT, TEMPC,
    *                 LRAIN

! Assure that proper weather option is used in the stand model.
! this is only used in the stand alone version of the stand model.
! --IF (IWOPT .NE. 4) THEN
    WRITE (*, *) ' IWOPT not properly set to 4; will reset!'
    IWOPT = 4
    RAUSE
! --ENDIF

! End of addition for iwopt under stand damage model.

! Open the weather data file:
OPEN (20, FILE = 'ANNDDSUM.D1S', STATUS = 'OLD')
JWIN = 20

! No longer open the rain data file: RAINDATA, if logical variable calls
! for it, write an error message. Rain is only used by Gypsy Moth
submodel.

    IF (LRAIN) WRITE (*, 10060)

!
c Call subroutine INITW to initialize weather variables.
222 c Call subroutine TINIT to initialize stand & tree variables & parameters
223 c Call subroutine PINIT to print initial stand conditions and parameter
224 c settings.
225 c Call subroutine THGHTS to calculate tree heights for each species and
226 c diameter class.
227 c
228 |
229 |   CALL INITW()
230 |
231 |   CALL TINIT()
232 |   CALL PINIT()
233 |
234 |   CALL THGHTS()
235 |
236 |   IF (DEBUG) WRITE (JDB, 10070)
237 |
238 c Do the following for each year in the simulation.
239 c Set output counters. IPYEAR = the interval (in years) that
240 c stand output is to be printed (default = every year). KYEAR = no.
241 c of years since output was last printed. IYEAR = number of
242 c current year. Ensure that output is printed after the 1st year.
243 c If IPYEAR=0, then output will be printed only in years specified
244 c by IVIEWS; MV=counter that points to next year to be printed.
245 c ISYEAR = current year (ex: 1980).
246 |
247 |   MV = 1
248 |   KYEAR = IPYEAR - 1
249 |   KGYEAR = 0
250 |   ISYEAR = ISYEAR - 1
251 |   ---DO IYEAR = 1, NYEARS
252 |     KYEAR = KYEAR + 1
253 |   KGYEAR = KGYEAR + 1
254 |   ISYEAR = ISYEAR + 1
255 |
256 c The stand submodel is running alone and total annual
257 c degree-days have been provided for each year (IWOPT = 4).
258 |
259 c Estimate foliage present by calling TREE1 (part of the
260 c Stand submodel)
261 |
262 |   CALL TREE1()
263 |
264 c Call RELSTK to compute relative stocking
265 |
266 |   CALL RELSTK()
267 |
268 c Call FLUPDT to estimate last year’s defoliation effect on this year’s
269 c foliage production.
270 |
271 |   CALL FLUPDT()
272 |
273 |   ++--IF (DEBUG) THEN
274 |   |   WRITE (JDB, 10090)
275 |   |   WRITE (JDB, 10100) UNDE(1), OVR(1)
c Simulate GM defoliation by calling Subroutine DEFOL
284 | | IF (DEBUG) WRITE (JDB, 10120)
285 | | ---ENDIF
286 | | ---ENDDO
287 | | ---END
288 | |
289 c Call TREE21, TREE22, WASCII, and GNXTMG:
290 c then check to see if it's time to print a stand table
291 |
292 c TREE21 - The initial portion of old TREE2.
293 c TREE22 - The big "by host" loop of TREE2.
294 c The above two routines will be further subdivided.
295 c WASCII - write the ASCII data to files as requested.
296 c GNXTMG - Get the Next Management date and type.
297 |
298 | | CALL TREE21()
299 | | CALL TREE22()
300 | | CALL WASCII()
301 | | CALL GNXTMG()
302 |
303 C | | IF (DEBUG) WRITE (JDB, 10130)
304 | | "---IF (STABLE) THEN"
305 | | | | "---IF (IPYEAR .EQ. 0) THEN"
306 | | | | | | "---IF (ISYEAR .EQ. IVIEW(MV)) THEN"
307 | | | | | | | | CALL TPRINT()
308 | | | | | | | | MV = MV + 1
309 | | | | | | | | "---ENDDO"
310 | | | | | | | "---ELSEIF (KYEAR .EQ. IPYEAR) THEN"
311 | | | | | | | | CALL TPRINT()
312 | | | | | | | KYEAR = 0
313 | | | | | | | "---ENDDO"
314 | | | | | | | "---ENDDO"
315 | |
316 c End of primary do loop for simulating each year.
317 c Check to see if the no. of years to be simulated (NYEARS)
318 c has been reached. If not, go on to the next year.
319 |
320 | | I = PGAUGE(IYEAR)
321 |
322 | | ---ENDDO
323 |
324 c Otherwise, end of simulation, do house cleaning.
325 |
326 |
327 c Print final Stand table.
328 |
329 | | IF (STABLE .OR. DEBUG) CALL PSTBL()
331 c Call clean for following:
  332 |
  333 | CALL CLEAN (ISOPT)
  334 | OPEN (8, FILE = 'GRAPHOST.DIS', STATUS = 'UNKNOWN')
  335 | JGRAPH = 8
  336 | WRITE(JGRAPH, 10140) NHOSTS, (TNAME(IH), IH=1, NHOSTS)
  337 | CLOSE (8)
  338 | RETURN
  339 | "--ENDIF"
  340 |
  341 |
342 c *** END of subroutine DAMAGE -- file name: DAMSR.FOR ***
***** Subroutine DEFOL, file: DEFOL.FOR *****
A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model.
Last revised by K.Sheehan January 1988; revised starting in 1989 by Colbert and Racin.
J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505
(304)-285-1600

Used when the stand submodel is used without the gypsy moth submodel. This section reads defoliation estimates provided by
the user and uses those rates to adjust the amounts of foliage present.
Called by the main program DAMSR.
No calls to other routines.

** Local variables, parameters, and inputs required by Subroutine DEFOL **
The following designations for LOCATIONS apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp: call parameter of this subroutine
(4) - a := subroutine called from within this code
(5) - XXN: CAPS or CAPS-digit indicate a common block name

NAME - LOCATION - DESCRIPTION
-----------------------------------------------
ACTFOL S3 - Actual foliage present.
(lh,is)
DEFL S3 - Defoliation this year.
(lh,is)
DEFO <Subroutine>
FOL S3 - Foliage produced, before defoliation.
(lh,is)
IDFOLY S3 - Year next defoliation will take place.
(lh,is)
IFSO 1 - IOSTAT return variable.
IH 1 - Host index
IS 1 - strata index
ISYEAR GEN1 - Current calendar year.
JDEF GEN1 - Defoliation data file handle.
LDEFOLOG1 Logical variable; true if defoliation trace activated.
LOG2 True if output is to be presented in metric units.
METRIC NHOSTS GEN1 - Number of (host) tree species used this sim.
-----------------------------------------------

SUBROUTINE DEFOL
INTEGER IFSO
10000 FORMAT (1X, F3.0)
10010 FORMAT (1X, I4)

**** Include blocks ****

INCLUDE 'GEN1.CMB'
INCLUDE 'LOG2.CMB'
INCLUDE 'ION.CMB'

59 c If defoliation has been scheduled and the year is correct, then get
60 c the defoliation data.
61       +--IF (LDEFOL .AND. (ISYEAP .EQ. IDFOLY)) THEN
62       |
64 c The % defoliation for the current year is read into the model
65 c and used to reduce actual foliage present (ACTFOL).
66       | READ (JDEP, 10000) (DEFL(IH, 1), IH = 1, NHOSTS)
67       | READ (JDEP, 10000) (DEFL(IH, 2), IH = 1, NHOSTS)
69 c get IDFOLY = the next year that has defoliation scheduled.
71       | READ (JDEF, 10010, IOSTAT = IFSU) IDFOLY
73 c If EOF, another year (IDFOLY) not present so quit trying to read data.
75       | +--IF (IFS0 .LT. 0) THEN
76       | |  IDFOLY = 0
77       | +--ENDIF
78       | +--DO IH = 1, NHOSTS
79       | | +--DO IS = 1, 2
80       | || +--IF (METRIC) THEN
81       | || | ACTFOL(IH, IS) =
82       *| || | FOL(IH, IS) * (1.0 - (DEFL(IH, IS)/100.0))
83       | || | +--ELSE
84 c Conversion of kilograms per hectare to pounds per acre:
85       | || | ACTFOL(IH, IS) =
86       | *| || | FOL(IH, IS) * (1.0 - (DEFL(IH, IS)/100.0)) *
87       *| || | 1.12086
88       | || | +--ENDIF
89       | +--ENDDO
90       | +--ENDDO
91 c If IDEFOL is false or defoliation has not been scheduled for
93 c this year then no defoliation will occur - set all
94 c values of DEFL to zero and ACTFOL to FOL.
95 c
96       +--ELSE
97       | +--DO IH = 1, NHOSTS
98       | | +--DO IS = 1, 2
99       | | | DEFL(IH, IS) = 0.0
100      | | +--IF (METRIC) THEN
101      | | | ACTFOL(IH, IS) = FOL(IH, IS)
102      | | | +--ELSE
103      | | | ACTFOL(IH, IS) = FOL(IH, IS) * 2.2046
104      | | | +--ENDIF
105      | | +--ENDDO
106      | +--ENDDO
107      +--ENDIF
108      RETURN
109      END
110 c ***** END of subroutine DEFOL, file name: DEFOL.FOR *****
**** Subroutine FLUPDT, file: FOLUPDTE.FOR ******

A portion of the:

Stand-Damage Model - a portion of the Gypsy Moth Life System Model (the stand submodel) converted to a stand-alone model. Last revised by K. Sheehan January 1988; revised starting in 1989 by Colbert and Racin.

J. Colbert, Northeastern Forest Experiment Station 180 Canfield St., Morgantown, WV 26505 (304)-285-1600

This is a part of the Stand-Damage Model, part of the Gypsy Moth Life System Model. This subroutine calculates the function that accounts for the effects of last year's defoliation on this year's foliage production. DEFL = % defoliation last year. This simple linear function was arbitrarily selected by K. SHEEHAN.

Called by the main program DAMSR.

No calls made to other routines.

** Local variables, parameters, and inputs required by Subroutine FLUPDT **

The following designations for LOCATIONs apply:

- 1 : local variable
- n : new parameter; not yet assigned to a common block
- cp : call parameter of this subroutine
- s : subroutine called from within this code
- XXX : CAPS or CAPS-digit indicate a common block name

NAME - LOCATION - DESCRIPTION
---------------------------------------------
DEFL  S3 - Percent defoliation, by host and strata
DFOLDE S3 - Slope of defoliation curve
FOL  S3 - Potential foliage biomass by host and strata
IH  1 - Host index
IS  1 - Index for overstory and understory
IYEAR  GEN1 - Current year in the simulation
LYEAR  1 - "Last year"
HOSTS GEN1 - Number of hosts to be simulated

SUBROUTINE FLUPDT

**** Include blocks ****

INCLUDE 'GEN1.CMB'
INCLUDE 'S3.CMB'

LYEAR = IYEAR - 1
DO IH = 1, HOSTS
| IF (LYEAR .NE. 0) FOL(IH, IS) = FOL(IH, IS) * (1.0 -
| (DEFL(IH, IS)/100.0) * DDFOLDE)
| ENDDO

END

C *** End of Subroutine FLUPDT -- File name: FOLUPDTE.FOR ***
***** Subroutine GNXTMG, file: GETNXTMG.FOR *****

A portion of the:
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(the stand submodel) converted to a stand-alone model. Last
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J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-295-1600

This section brings in the next management year and action type.
Called from main program DAMSR.
No subroutines are called by this routine.

** local variables, parameters, and inputs required
by subroutine GNXTMG **

the following designations for locations apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) -XXN:= caps or caps+digit indicate a common block name

-----------------------------------
Name - Location - Description
-----------------------------------
ISYEAR   GEN1 - Current calendar year
JTIN     GEN1 - Input handle for file TREEDATA.D1S: stand & tree--
data and parameters.
MANAGE   S4  - Management type code: 1 or 2 only.
MTOTAL   S4  - Total number of management entries for this
simulation.
MYEARS   S4  - Management year of next scheduled entry.
-----------------------------------

SUBROUTINE GNXTMG

10000 FORMAT (1X, I4, 1X, I1)

**** Include blocks ****

INCLUDE 'GEN1.CMB'
INCLUDE 'S4.CMB'

If stand management has taken place this year, MYEARS is equal to
ISYEAR, and if there is additional management to follow, MTOTAL is
greater than 0, so get the next year in which management will take
place, MYEARS, and the management type, MANAGE, after decrementing
by 1, the number of management years remaining.

+-IF (MTOTAL .GT. 0 .AND. MYEARS .EQ. ISYEAR) THEN
MTOTAL = MTOTAL - 1
READ (JTIN, 10000) MYEARS, MANAGE

RETURN
END

End of subroutine GNXTMG -- file name GETNXTMG.FOR
***** Subroutine GTCRWD, file: GETCROWD.FOR *****

A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
revised by K. Sheehan January 1989; revised starting in 1989
by Colbert and Racin.

J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

Called by TREE21.
No subroutines are called by this routine.
** Local variables, parameters, and inputs required
by Subroutine GTCRWD **
The following designations for LOCATIONs apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXX := CAPS or CAPS-digit indicate a common block name

---

NAME - LOCATION - DESCRIPTION
---

CROWD  S2  - Crowding index (a tree growth modifier)
CRWDMN S2  - Minimum crowding index value; parameter available
to user.
RSMULT S2  - Relative stocking multiplier, used to account for
the effects of relative stocking on tree growth
RSTOCK S3  - Relative stocking index for the stand

SUBROUTINE GTCRWD

**** Include blocks ****
INCLUDE 'S2.CMB'
INCLUDE 'S3.CMB'

Calculate the stand competition factor ("CROWD") as a function of the
relative stocking index (RSTOCK, calc. a la Silvah) and RSMULT
(arbitrarily set by K. Sheehan). CROWD is constrained and has a minimum
value of 0.75, the user accessible value of the parameter CRWDMN.

CROWD = 1.0 - (RSTOCK*RSMULT)
IF (CROWD .LT. CRWDMN) CROWD = CRWDMN

RETURN
END

50

End of subroutine GTCRWD -- file name GETCROWD.FOR
***** Subroutine INITW, file: INITW.FOR *****

A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(revised by K. Sheehan January 1988; revised starting in 1989
by Colbert and Racini.

J. Colbert, Northeastern Forest Experiment Station
180 Confield St., Morgantown, WV 26505 (304) 285-1600

Read parameter values & initial conditions from file with handle JWIN
Called by the main program DAMSR.
No calls made to other routines.

** Local variables, parameters, and inputs required
by Subroutine INITW **

The following designations for LOCATIONS apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXN := CAPS or CAPS-digit indicate a common block name
(6) - G := GLOBAL Microsoft parameter.

NAME - LOCATION - DESCRIPTION
-----------------------------------------------
ANND - (100) - Total annual degree days for each year of simulation
up to 100 years possible.
DEBUG LOGI - Logical variable, true for DEBUG output generation
IFS0 1 - Local variable holding READ error return code.
IOSTAT g - FORTRAN I/O status parameter.
IY 1 - Year index for reading annual totals of degree-days
for each year (IY = 1, ..., NYEARS).
JDB GEN1 - Logical unit number for DEBUG output writing.
JWIN GEN1 - Logical unit number for weather data input.
NYEARS GEN1 - Number of years to simulate; less than or equal to
100.

SUBROUTINE INITW

INTEGER IFS0

10000 FORMAT (' INITW;1010: NYEARS = ', I3)
10010 FORMAT (F7.1)
10020 FORMAT (' INITW;2000: IY, ANND(IY)'/'100(I1X, I4, 3X, F8.2/))

INCLUDE 'GEN1.CMB'
INCLUDE 'WTHR1.CMB'
INCLUDE 'LOG1.CMB'

Read weather information.

**********************************************************************
56      REWIND (JWIN)
57      IF (DEBUG) WRITE (JDB, 10000) NYEARS
58      READ (JWIN, 10010, IOSTAT = IFS0) (ANNDD(IY), IY = 1, NYEARS)
59      IF (IFS0 .LT. 0) WRITE(*, *) 'EOF found on file handle JWIN =',
60      " JWIN
61      IF (DEBUG) WRITE (JDB, 10020) (IY, ANNDD(IY), IY = 1, NYEARS)
62      RETURN
63      END
64
65 c *** END of subroutine INITW -- file name: INITW.FOR ***
***** Subroutine PINIT, file: PINIT.FOR *****
A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
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by Colbert and Racin.
J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600
Print parameter values & initial conditions for the STAND submodel.
Called by the main program DAMSR.
Calls made by this routine to PNOTE and PTSTBL.
** Local variables, parameters, and inputs required
by Subroutine PINIT **
The following designations for LOCATIONs apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXN := CAPS or CAPS-digit indicate a common block name
---
NAMF - LOCATION - DESCRIPTION
-----------------------------------------------
AGEMAX S1 - Maximum tree age by host
BDIE S1 - Background tree mortality rate, by host
B1 S1 - For calculating tree height
B2 S1 - For calculating tree height
COLD S1 - Minimum annual degree-days tolerated, by host
CR1 S1 - CR(1-4): tree species specific parameters for
CR2 S1 - predicting live crown ratio from stand basal area
CR3 S1 and tree diameter.
CR4 S1
OMAX S1 - Maximum DBH (cm.) by host
FDIE S1 - Proportion of trees that die because of defol.,
based on host, no. of years of defol., and site
F1 S1 - For calculating foliage biomass / tree
F2 S1 - For calculating foliage biomass / tree
GROWR S1 - For calculating potential annual diam. growth
HMAX S1 - Max. height (cm.), by host
HOT S2 - Max. annual degree-days tolerated, by host
HOVER S2 - Height or diam. that separates over- & understory
trees
I 1 - Index
IBOUND S4 - Overstory/understory boundary type: 1 = height (ft
or cm), 2=diam. (in or cm)
IDHIST S3 - Defoliation history for past two years: 0 = none,
1=light, 2 = medium, 3=heavy; by host and strata
IH 1 - Host index
IPYEAR GEN1 - Interval in years for printing stand output
IS 1 - Index for overstory and understory
ISEED GEN1 - Random number seeds: 1=recruitment of new trees,
2=not used at this time, 3=additional tree
mortality due to stress, 4=add. gypsy moth
56 c mortality due to winter temp., 5s for weather
generation, 6s GM L1 disp.
57 c ISHADE S4 Shade tolerance class by species (2=diam. growth,
1=recruitment)
58 c ISITE S4 Index for site (1=moist, 2-intermediate, 3-dry)
59 c ISOPT S4 Tree stress option (1=stress occurs in random
60 c years, 2=user specifies stress years
61 c ISTOKG S1 Relative stocking class, by host
62 c ISTR S4 Array to hold the years that stress will occur
(set by user) -- used for table display only.
63 c ISTRYR S4 Use to decide when to add stress STRPAC(2) as SDIE
64 c ISYEAR GEN1 Starting year; example: 1987
65 c IWOPT GEN1 Weather option(1=1 yr of data, 2=>1 yr of data
66 c 3= generate data with subr. WGEN. 4 = use annual
70 c total degree-days (GMOTH)
71 c IY 1 Year index
72 c J 1 Index
73 c JSOUT1 GEN1 File number: stand output
74 c JSTKS GEN1 File number: stress years
75 c K 1 Index
76 c LDPFOL LOG2 True if data to be read in from LUN 14=JDEF
77 c METRIC LOG2 True if input/output units are to be metric
78 c MTOTAL S4 Total management years
79 c NDIF S1 Number of years of heavy defoliation (above 65%)
80 c NHOSTS GEN1 Number of hosts to simulate
81 c NLINES GEN1 Number of lines
82 c NTRYR S4 Number of stress years
83 c NWEARY GEN1 Number of years of weather data provided by user
84 c NYEARS GEN1 Number of years to be simulated
85 c NSTEM S3 Total sample plot area -- used to calculate
86 c number of stems/ha
87 c PLOTAR S2 Area for calc. influence of surrounding trees on
88 c shading of a given tree
89 c PRNOTE s
90 c PTSTBL s
91 c RECRUT S1 Maximum number of seedlings that can be recruited
92 c into the smallest diameter class, by host
93 c RRSTIN S1 Number of resting sites per 100 sq. cm., by host
94 c and location of tree
95 c RNSCP1 CHAR1 User supplied char. strings (input data file name)
96 c RNSCP2 CHAR1 User supplied char. strings (user name)
97 c RNSCP3 CHAR1 User supplied char. strings (job name)
98 c RNSCP4 CHAR1 User supplied char. strings (site name)
99 c RNSCP5 CHAR1 User supplied char. strings (date)
100 c RSMU/T S Relative stocking index for the stand
101 c SHADMN S1 Minimum value for SHADE in equation 16. This
102 c minimum value is used for all species & diameters.
103 c SHX S1 Effect of light on diam. growth by shade tolerance
104 c index
105 c SHY S1 Effect of light on diam. growth by shade tolerance
106 c index
107 c SLOWD S1 Minimum annual growth needed to avoid additional
108 c mortality
109 c STABLE LOG2 True if stand submodel output is desired
SUBROUTINE PINT


10010  FORMAT (16X, 'DAMAGE MODEL VERSION 1.1: ', A20)

10020  FORMAT (' No. of Years to be Simulated: ', I4, T50, 'UNITS: ', A7, T80, 'RANDOM NUMBER SEEDS -- '/

10030  FORMAT (' First Year of Simulation: ', I4, T50, 'Stand Area: ', F7.1, 1X, A2, T90, 'Stem Recruitment: ', I7, /

10040  FORMAT (' Output to be produced Every ', I2, ' Years', T50, 'Total Sample Plot area: ', F7.1, 1X, A2, T90, 'Add. Tree Mort: ', I7, /

10050  FORMAT (' Due to Stress: ', I7, T50, 'Site moisture Index: ', I2)

10060  FORMAT (' No Defoliation prescribed for this simulation.')

10070  FORMAT (' Defoliation data will be read from file: ' , A50, 'DEFOILAT.DIS')

10080  FORMAT (' OVERSTORY / UNDERSTORY BOUNDARY (BASED ON ', A7, ' HEIGHT: ', F7.2, ' (' , A2, ')')

10090  FORMAT (' DIAMETER: ', F7.2, ' (' , A2, ')')

10100  FORMAT (' SHADING PARAMETERS: TLIGHT= ', F4.2, 2X, 'TKL= ', F4.2, 2X, 'PLOT SIZE FOR SHADING= ', F7.4, 1X, A2, '/

10110  FORMAT (' EFFECT OF AVAL. LIGHT ON DIAM. GROWTH, BY TOLERANCE', ' CLASSES (PROP. AVAL. LIGHT, PROP. OF POT. GROWTH):/', ' TOL. CLASS: ', 1X, A2, '1', '2', '3', '4', '5', '6', '7', '8', '9', '10X, 6(F7.2, ', '5)', '/

10120  FORMAT (' EFFECT OF REL. STOCKING ON ', ' DIAMETER GROWTH: ', F7.4, ' EFFECT OF REL. STOCKING ON ', ' RECRUITMENT, BY TOLERANCE CLASSES (REL. STOCKING, PROP. ', ' OF POT. RECRUIT.):/' ' TOL. CLASS: ')

55
08-10-94 21:00:50 PINIT.FOR Pg 4
Tue 08-16-94 17:06:13 PINIT of 8

166 * '1, 2, 3, 4, 5',
167 * '6', /13X, 6(' ' ' ' ' '), 4(12X, 6(6.0, ',',')
168 * F5.2)/)
169 10090 FORMAT (' ' PROBABILITY THAT DEFOLiated TREES HAVE '
170 * 'ADDITIONAL MORTALITY DUE TO STRESS = ', F7.3)
171 10100 FORMAT (' ' DEFOLiated TREES MAY HAVE ADDITIONAL MORTALITY',
172 * 'DUE TO STRESS IN THE FOLLOWING YEARS: '/)
173 10110 FORMAT (1X, I4)
174 10120 FORMAT (10X, I5(I4, 2X))
175 10130 FORMAT (' 'No additional stress included (ISOPT = 0).')
176 10140 FORMAT (' 'ADDITIONAL MORTALITY IN YEARS WITH NO STRESS: ',F5.2,
177 * 'IN YEARS WITH STRESS: ', F5.2/)
178 10150 FORMAT (1X, I5, ' YEARS OF WEATHER DATA READ FROM FILE WDATA. '
179 10160 FORMAT (3X, I3, ' YEARS OF WEATHER DATA GENERATED FROM ',
180 * 'PARAMETERS IN FILE WDATA. ')
181 10170 FORMAT (2X, I3, ' Years of weather summary data, accumulated ',
182 * 'degree-days for each year in data file: ANNDDSUM.DIS')
183 10180 FORMAT (' 'Tree Threshold Temperature: ', F6.1, 5X,
184 * 'Temperature Multiplier: ', F6.1, 5X, 'Minimum Value for ')
185 * 'variable TEMP: ',/14.2)
186 10190 FORMAT (' 'PARAMETERS THAT VARY WITH TREE SPECIES --', //
187 * 'SPECIES CODE: ', 13X, 12(6X, A3))
188 10195 FORMAT (34X, 12(A))
189 10200 FORMAT ('Relative Stocking Class', 7X, 12(8X, I1))
190 10210 FORMAT ('Recruitment Tolerance Class', 12(8X, I1))
191 10220 FORMAT ('Diam. Growth Tolerance Class', 12(8X, I1))
192 10230 FORMAT ('Maximum Diam. (', A2, ',')', 12X, 12(4X, F5.0))
193 10240 FORMAT ('Maximum Height (', A2, ')', 12X, 12(2X, F7.0))
194 10250 FORMAT ('Maximum Age (Years)', 12X, 12(4X, F5.0))
195 10260 FORMAT ('Minimum Annual Day-Deg.s', 7X, 12(2X, F7.0))
196 10270 FORMAT ('Maximum Annual Day-Deg.s', 7X, 12(2X, F7.0))
197 10280 FORMAT ('Diam. Growth Parameter', 7X, 12(3X, F6.1))
198 10290 FORMAT ('Height Parameter B1 ', 11X, 12(2X, F7.2))
199 10300 FORMAT ('Height Parameter B2 ', 10X, 12(2X, F7.4))
200 10310 FORMAT ('Foliage Biomass Param. P1 ', 5X, 12(1X, F8.5))
201 10320 FORMAT ('Foliage Biomass Param. P2 ', 5X, 12(2X, F7.4))
202 10330 FORMAT ('Surface Area:Biomass Ratio', 4X, 12(4X, F5.1))
203 10340 FORMAT ('Max. Annual Tree Recruitment ', 12(3X, F6.0))
204 10350 FORMAT ('Bole Resting Sites / 100 sq. cm', 12(2X, F7.4))
205 10355 FORMAT ('Bole Resting Sites / sq. ft. ', 12(2X, F7.4))
206 10360 FORMAT ('Crown Resting Sites / 100 sq. cm', 12(2X, F7.4))
207 10365 FORMAT ('Crown Resting Sites / sq. ft. ', 12(2X, F7.4))
208 10370 FORMAT ('Live Crown Ratio Parameters 1 ', 12(3X, F6.2))
209 10380 FORMAT (29X, '2: ', 12(2X, F7.4))
210 10390 FORMAT (29X, '3: ', 12(4X, F5.2))
211 10400 FORMAT (29X, '4: ', 12(3X, F6.3))
212 10410 FORMAT ('Add. Mort. When Growth Slowed ', 12(3X, F6.3))
213 10420 FORMAT ('Base mortality rate ', 5X, 12(1X, F8.5))
214 10430 FORMAT ('/')
215 10440 FORMAT ('Tree Mortality Ratec Following Heavy Defoliation:',
216 * /14X, 'YEARS OF HEAVY DEFOL. ', 'SPECIES', 6X, '1', 8X, '2',
217 * 8X, '3', /, '-----', 3(4X, '-----'), 12(/, 4X, A3, 1X, 3F9.2)
218 * ,//
219 10450 FORMAT ('No Stand Treatments Scheduled')/
220 10460 FORMAT ('STAND TREATMENTS SCHEDULED: ', I4, 'years have ')
221  *  'been requested; input parameters', 35X, 'and results will'
222  *  'be printed at the years requested.'/
223 10470  FORMAT ('DEFOLIATION HISTORY:', 1X, 12(6X, A3, 3X))
224 10480  FORMAT (25X, 12(A))
225 10490  FORMAT ('% Defol. 1 Year Ago:', 12(1X, I5, I6))
226 10500  FORMAT ('% Defol. 2 Years Ago:', 12(1X, I5, I6))
227 10510  FORMAT (//)
228
229 c ** Common Blocks included:
230
231    INCLUDE 'CHAR1.CMB'
232    INCLUDE 'GEN1.CMB'
233    INCLUDE 'LOG1.CMB'
234    INCLUDE 'LOG2.CMB'
235    INCLUDE 'S1.CMB'
236    INCLUDE 'S2.CMB'
237    INCLUDE 'S3.CMB'
238    INCLUDE 'S4.CMB'
239    INCLUDE 'WTHR1.CMB'
240 c
241  FILE HANDLES FOR OUTPUTS:
242 c  File No.  Var. Name
243  13 = Stand table   JSOUT1
244  15 = Stand graph file - No. Stems   JSOUT2
245  16 = Stand graph file - Basal Area   JSOUT3
246  17 = Stand graph file - Volume   JSOUT4
247  18 = Stand graph file - DBH   JSOUT5
248 c
249  FILE HANDLES FOR INPUTS:
250 c  File No.  Var. Name
251  14 = Defoliation estimates   JDEF
252
253 c *******************************************
254 c Print initial conditions
255 c *******************************************
256  +--IF (STABLE) THEN
257     | WRITE (JSOUT1, 10000) RNSPC1, RNSPC2, RNSPC3, RNSPC4, RNSPC5
258     | +--IF (NLINES .GT. 0) THEN
259     | | WRITE (JSOUT1, '('/'))
260     | | CALL PRNOTE(JSOUT1, NLINES)
261     | +--ENDIF
262     | WRITE (JSOUT1,'(A1)') ''C
263     | WRITE (JSOUT1, 10010) 'PARAMETER VALUES'
264     |
265     | +--IF (METRIC) THEN
266     | | UNITS = 'METRIC'
267     | | UNITS2 = 'HA'
268     | | UNITS3 = 'CM'
269     | | UNITS4 = 'M.'
270     | +--ELSE
271     | | UNITS = 'ENGLISH'
272     | | UNITS2 = 'AC'
273     | | UNITS3 = 'IN'
274     | | UNITS4 = 'FT'
275     | +--ENDIF
276  |    | --IF (METRIC) THEN
277  |    |     WRITE (JSOUT1, 10020) NYEARS, UNITS, ISYEAR, STNDAR,
278  |    |     UNITS2, ISEED(1), IPYEAR, PLOTR,
279  |    |     UNITS2, ISEED(3), ISITE
280  |    | --ELSE
281  |    |     WRITE (JSOUT1, 10020) NYEARS, UNITS, ISYEAR,
282  |    |     (STNDAR*2.471044), UNITS2, ISEED(1),
283  |    |     IPYEAR, (PLOTR*2.471044), UNITS2,
284  |    |     ISEED(3), ISITE
285  |    | --ENDIF
286  |    | --IF (LUEPOL) THEN
287  |    |     WRITE (JSOUT1, 10040)
288  |    | --ELSE
289  |    |     WRITE (JSOUT1, 10030)
290  |    | --ENDIF
291  |    | --IF (METRIC) THEN
292  |    |     --IF (JBOUND .EQ. 1) THEN
293  |    |     WRITE (JSOUT1, 10050) HOVER/100.0, UNITS4
294  |    |     --ELSE
295  |    |     WRITE (JSOUT1, 10060) HOVER, UNITS3
296  |    |     --ENDIF
297  |    |     WRITE (JSOUT1, 10070) TLIGHT, TKL, SHADMN, PLOTSZ, UNITS2,
298  |    |     ((SHX(K, J), SHY(K,J), K = 1, 6), J = 1, 4)
299  |    | --ELFINF (JBOUND .EQ. 1) THEN
300  |    |     WRITE (JSOUT1, 10050) (HOVER/10.48), UNITS4
301  |    |     WRITE (JSOUT1, 10070) TLIGHT, TKL, SHADMN, PLOTSZ*2.471044,
302  |    |     UNITS2, ((SHX(K, J), SHY(K,J), K = 1, 6), J = 1, 4)
303  |    | --ELSE
304  |    |     WRITE (JSOUT1, 10060) (HOVER/2.54), UNITS3
305  |    |     WRITE (JSOUT1, 10070) TLIGHT, TKL, SHADMN, PLOTSZ*2.471044,
306  |    |     UNITS2, ((SHX(K, J), SHY(K,J), K = 1, 6), J = 1, 4)
307  |    | --ENDIF
308  |    |     WRITE (JSOUT1, 10080) RSMULT, ((STOKX(I, J), STOKY(I, J), I = 1, 6), J = 1, 4)
309  |    |
310  |
311  |
312  |    | --IF (ISOPT .EQ. 1) THEN
313  |    |     WRITE (JSOUT1, 10090) X
314  |    | --ELSEIF (ISOPT .EQ. 2) THEN
315  |    |     WRITE (JSOUT1, 10100)
316  |
317  c ISTR(YEAR) = Years that users specifies are stress years.
318  c 'This array is used only for the display of data that is read
319  c into this routine for inclusion in the output table. The file
320  c that contains the years that stress will occur is then re-
321  c wound and the first value is placed in variable ISTRYR for use
322  c in TREE21 to decide when to add the stress STRFAC(2) as SDIE.
323  c OPEN (11, FILE = 'STRESYRS.DLS', STATUS = 'OLD')
324  |
325  |
326  |
327  |
328  |
329  |
330  | --ENDDO
|
| READ (JSTRS, 10110) (ISTR(IY), IY = 1, NYRS)
| WRITE (JSOUT1, 10120) (ISTR(IY), IY = 1, NYRS)
| REWIND (JSTRS)
| READ (JSTRS, 10110) ISTRYR
| NSTRYR = NSTRYR - 1
| +-- ELSE
| WRITE (JSOUT1, 10130)
| +-- ENDIF
| WRITE (JSOUT1, 10140) STRFAC(1), STRFAC(2)
| +-- IF (IWOPT .LT. 3) THEN
| WRITE (JSOUT1, 10150) NWEAYR
| +-- ELSEIF (IWOPT .EQ. 3) THEN
| WRITE (JSOUT1, 10160) NWEAYR
| +-- ELSE
| WRITE (JSOUT1, 10170) NYEARS
| +-- ENDIF
| WRITE (JSOUT1, 10180) TRETHR, TFAC, TEMPMN
| WRITE (JSOUT1, 10190) (TNAME(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10195) (' --- ', I = 1, NHOSTS)
| WRITE (JSOUT1, 10200) (ISTOKS(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10210) (ISHADE(I, 1), I = 1, NHOSTS)
| WRITE (JSOUT1, 10220) (ISHADE(I, 2), I = 1, NHOSTS)
| +--IF (METRIC) THEN
| WRITE (JSOUT1, 10230) UNITS3, (DMAX(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10240) UNITS4, (HMAX(I)/100.0, I=1, NHOSTS)
| +-- ELSE
| WRITE (JSOUT1, 10250) AGEMAX(I), I = 1, NHOSTS)
| +-- ENDIF
| WRITE (JSOUT1, 10260) (COLD(I)/1.8, I = 1, NHOSTS)
| WRITE (JSOUT1, 10270) (HOT(I)/1.8, I = 1, NHOSTS)
| +-- ELSE
| WRITE (JSOUT1, 10280) (COLD(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10290) (HOT(I), I = 1, NHOSTS)
| +-- ENDIF
| WRITE (JSOUT1, 10300) (B1(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10310) (F1(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10320) (F2(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10330) (SURFAR(I), I = 1, NHOSTS)
| +--IF (METRIC) THEN
| WRITE (JSOUT1, 10340) (RECRUT(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10350) (RESTIN(I, 1), I = 1, NHOSTS)
| WRITE (JSOUT1, 10360) (RESTIN(I, 2), I = 1, NHOSTS)
| +-- ELSE
| WRITE (JSOUT1, 10370) (RECRUT(I)*0.404687, I = 1, NHOSTS)
| WRITE (JSOUT1, 10375) (RESTIN(I, 1)*9.29, I = 1, NHOSTS)
| WRITE (JSOUT1, 10380) (RESTIN(I, 2)*9.29, I = 1, NHOSTS)
| +-- ENDIF
| WRITE (JSOUT1, 10390) (CR1(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 10395) (CR2(I), I = 1, NHOSTS)
| WRITE (JSOUT1, 103990) (CR3(I), I = 1, NHOSTS)
386       WRITE (JSOUT1, 10400) (CR4(I), I = 1, NHOSTS)
387       +--IF (METRIC) THEN
388       WRITE (JSOUT1, 10410) (SLOWD(I), I = 1, NHOSTS)
389       +--ELSE
390       WRITE (JSOUT1, 10410) ((SLOWD(I)/2.54001), I = 1, NHOSTS)
391       +--ENDIF
392       WRITE (JSOUT1, 10420) (BDIE(I), I = 1, NHOSTS)
393       WRITE (JSOUT1, 10430)
394       WRITE (JSOUT1, 10440) (TNAME(I), (FDIE(I), NDEF, ISITE),
395       *  NDEF = 1, 3), I = 1, NHOSTS)
396       |
397       |
398       +--IF (MTOTAL .EQ. 0) THEN
399       WRITE (JSOUT1, 10450)
400       +--ELSE
401       WRITE (JSOUT1, 10460) MTOTAL
402       MTOTAL = MTOTAL - 1
403       +--ENDIF
404       WRITE (JSOUT1, '(A1)') ' \f c
405       WRITE (JSOUT1, 10010) ' INITIAL CONDITIONS'
406       CALL PTSTBL()
407       WRITE (JSOUT1, 10470) (TNAME(I), I = 1, NHOSTS)
408       WRITE (JSOUT1, 10480) (' OVER UNDER ', 1 = 1, NHOSTS)
409       WRITE (JSOUT1, 10480) (' ---- ----- ', I = 1, NHOSTS)
410       WRITE (JSOUT1, 10490) ((IDHIST(IH, IS, I), IS = 1, 2),
411       *  IH = 1, NHOSTS)
412       WRITE (JSOUT1, 10500) ((IDHIST(IH, IS, 2), IS = 1, 2),
413       *  IH = 1, NHOSTS)
414       WRITE (JSOUT1, 10510)
415       |
416       +--ENDIF
417       RETURN
418       END
419
420 c *** END of subroutine PINIT -- file PINIT.FOR
***** Subroutine PRNOTE, file: PRNTNOTE.FOR *****
A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
revised by K. Sheehan January 1988: revised starting in 1989
by Colbert and Racin.

J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

Produces a copy of the user's input notes as part of the output
and writes them to the Stand Table file.
Called from: subroutine PINIT, at the beginning of the writing of the
Stand Table output.
No calls to other routines.

** Local variables, parameters, and inputs required
by Subroutine PRNOTE(OUTHDL, LENGTH) **
The following designsations for LOCATIONS apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXN := CAPS or CAPS-digit indicate a common block name
---
NAME - LOCATION - DESCRIPTION
---
BUFFERS 1 - Text buffer
IFILE 1 - File handle for opening input data file.
J 1 - Index
LENGTH cp - Number of lines in notes file
OUTHDL cp - Output device handle (number).
---
SUBROUTINE PRNOTE(OUTHDL, LENGTH)
FORMAT (/.*, 5X,
* 'User notes supplied through the Setup-Edit Job Description',/)

CHARACTER*75 BUFFER
INTEGER OUTHDL, LENGTH

IFILE = 19
OPEN (IFILE, FILE = 'USERNOTE.D1S', STATUS = 'OLD')
WRITE (OUTHDL, 10000)

--- DO J = 1, LENGTH
| READ (IFILE, '(A)') BUFFER
| WRITE (OUTHDL, '(A)') BUFFER
--- ENDDO
CLOSE (IFILE)
RETURN
END
---

***** End of subroutine PRNOTE, file: PRNTNOTE.FOR
1 c ***** Subroutine PRTMGT, file: PRTMGT.FOR *****
2 c A portion of the:
3 c Stand-Damage Model - a portion of the Gypsy Moth Life System Model
4 c (the stand submodel) converted to a stand-alone model. Last
5 c revised by K. Cheesman January 1988, revised starting in 1989
6 c by Colbert and Racin.
7 c
8 c J. Colbert, Northeastern Forest Experiment Station
9 c 180 Canfield St., Morgantown, WV 26505 (304)-285-1600
10 c
11 c Writes the stand management treatments that have been scheduled
12 c to the Stand Table file.
13 c Called by subroutine TREE21.
14 c No calls made.
15 c
16 c ** Local variables, parameters, and inputs required
17 c by Subroutine PRTMGT **
18 c The following designations for LOCATIONa apply:
19 c (1) - l := local variable
20 c (2) - n := new parameter; not yet assigned to a common block
21 c (3) - cp := call parameter of this subroutine
22 c (4) - s := subroutine called from within this code
23 c (5) - XXN := CAPS or CAPS-digit indicate a common block name
24 c
25 c NAME - LOCATION - DESCRIPTION
26 c --------------------------------------------------------------
27 c CUTMAX S4 - Maximum diam. to be cut, by host and year
28 c CUTMIN S4 - Minimum diam. to be cut, by host and year
29 c IH 1 - Host tree species counter.
30 c MANAGE GEN1 - File number: stand output
31 c S4 - Stand management option: 0= no actions, 1= user
32 c specifies proportions to be cut, 2= user specifies target no. of stems
33 c METRIC LOG2 - True if input/output units are to be metric
34 c MYEARS S4 - Yrs that management actions have been scheduled
35 c NHHOSTS GEN1 - Number of hosts to be simulated
36 c NUMLIN GEN1 - Line counter for setting page eject on stand
37 c PFILE S4 - Table output file.
38 c PCUT S4 - Proportion of trees to be cut, by host and yr
39 c T 1 - Local variable for TARGET
40 c TARGET S4 - Target no. of residual stems (if MANAGE=2) for
41 c scheduled harvests, by yr and host
42 c TNAME CHAR1 - Tree code, by host
43 c UNITS S3 - Diameter limit units for treatment (cm).
44 c X 1 - Local variable for CUTMIN.
45 c Y 1 - Local variable for CUTMAX.
46 c
47 c SUBROUTINE PRTMGT
48 c
49 c 10000 FORMAT (/" STAND TREATMENTS SCHEDULED: USER HAS SPECIFIED ",
50 c * "TREATMENTS BY YEAR & SPECIES'/20X, 'PROPORTION NO.', 'STEMS',
51 c * '10X, 'DIAMETER LIMITS (' A2, ')', '/5X,
52 c * 'YEAR SPECIES TO BE CUT TO REMAIN MINIMUM ', 'MAXIMUM '
53 c * '/5X, " ---" " ---" " ---" " ---" ")/10X")
54 c
55 c
* '-------'/)
57 10010 FORMAT (5X, 14, 3X, A3, 7X, F7.2, 16X, F6.1, 6X, F6.1)
58 10020 FORMAT (5X, 14, 3X, A3, 17X, F7.2, 6X, F6.1, 6X, F6.1)
59 10030 FORMAT (1X)
60
61 c **** Common Blocks Included:
62
64 INCLUDE 'CHAR1.CMB'
65 INCLUDE 'GEN1.CMB'
66 INCLUDE 'LOG2.CMB'
67 INCLUDE 'S2.CMB'
68 INCLUDE 'S4.CMB'
69
70 WRITE (JSOUT1, 10000) UNITS3
71 NUMLIN = NUMLIN + 6
72
74 ---DO IH = 1, NHOSTS
75 | ++IF (METRIC) THEN
76 | | X = CUTMIN(IH)
77 | | Y = CUTMAX(IH)
78 | | T = TARGET(IH)
79 | ++ELSE
80 c | | 2.54001 cm/in. and 0.404687 ha/ac.
81 | | X = CUTMIN(IH)/2.54001
82 | | Y = CUTMAX(IH)/2.54001
83 | | T = TARGET(IH)*0.404687
84 | ++ENDIF
85 | ++IF (MANAGE.EQ. 1) THEN
86 | | WRITE (JSOUT1, 10010) MYEARS, TNAME(IH), PCUT(IH), X, Y
87 | | NUMLIN = NUMLIN + 1
88 | ++ELSE
89 | | WRITE (JSOUT1, 10020) MYEARS, TNAME(IH), T, X, Y
90 | | NUMLIN = NUMLIN + 1
91 | ++ENDIF
92 ++ENDDO
93 WRITE (JSOUT1, 10030)
94 NUMLIN = NUMLIN + 1
95
96 RETURN
97 END
98
99 c ***** End of subroutine PRTMG; file name: PRTMGIFM.FOR *****
1c **** Subroutine PTSTBL, file: PRNTSTBL.FOR ****
2c A portion of the:
3c Stand-Damage Model - a portion of the Gypsy Moth Life System Model
4c (the stand submodel) converted to a stand-alone model. Last
5c revised by K. Sheehan January 1988; revised starting in 1989
6c by Colbert and Racini.
7c
8c J. Colbert, Northeastern Forest Experiment Station
9c 180 Canfield St., Morgantown, WV 26505 (304)-285-1600
10c
11c Writes (Prints) the Stand Table (Stem counts by Species and Diameter
12c Class).
13c Called by the main program DAMSR and the subroutines
14c PINIT, TREE21, and TREE22.
15c No calls to other routines.
16c
17c
18c ** Local variables, parameters, and inputs required
19c by Subroutine PTSTBL **
20c The following designations for LOCATIONs apply:
21c (1) - 1 := local variable
22c (2) - n := new parameter; not yet assigned to a common block
23c (3) - cp := call parameter of this subroutine
24c (4) - s := subroutine called from within this code
25c (5) -XXN:= CAPS or CAPS-digit indicate a common block name
26c
27c NAME - LOCATION - DESCRIPTION
28c-----------------------------------------------
29c DIAM  S1  - Diameter at mid-point, by diam. class
30c ID  1  - Diameter index
31c IH  1  - Host index
32c JSOUT1  GEN1  - File number; stand output
33c METRIC  LOG2  - True if input/output units are to be metric
34c NDIAM  S4  - Number of diam. classes to be simulated
35c NHOSTS  GEN1  - Number of hosts to simulate
36c NUMLIN  GEN1  - Number of lines printed; used for page eject
37c STEMS  S1  - Number of stems, by host and diameter class
38c TNAME  CHAR1  - Tree code, by host
39c UNITS2  CHAR1  - 'HA' or 'AC'
40c UNITS3  CHAR1  - 'CM' or 'IN'
41c
42c SUBROUTINE PTSTBL
43c 10000 FORMAT (12X, 'NUMBER OF STEMS PER ', A2, ':', /64X,
44c * 'DIAMETER CLASS(', A2, ')/2X, 'SPECIES', 20F6.1/, 2X, 7(' - '),
45c * 1X, 20(' ----- '))
46c 10010 FORMAT (3X, A3, 3X, 20F6.2)
47c
48c **** Common blocks included:
49c INCLUDE 'CHAR1.CMB'
50c INCLUDE 'GEN1.CMB'
51c INCLUDE 'LOG2.CMB'
52c INCLUDE 'S1.CMB'
53c INCLUDE 'S4.CMB'
56 57 58  +--IF (METRIC) THEN
59      | WRITE (JSOUT1, 10000) UNITS2, UNITS3, (DIAM(ID), ID = 1,
60     * |    NDIAM)
61      |    NUMLIN = NUMLIN + 3
62      |    ++--DO IH = 1, NHOSTS
63      | | WRITE (JSOUT1, 10010) TNAME(IH), (STEMS(IH, ID), ID = 1,
64     * |    NDIAM)
65      |    NUMLIN = NUMLIN + 1
66      |    ++--ENDDO
67      +--ELSE
68      | WRITE (JSOUT1, 10000) UNITS2, UNITS3, ((DIAM(ID)/2.54001),
69     * |    ID = 1, NDIAM)
70      |    ++--DO IH = 1, NHOSTS
71      | | WRITE (JSOUT1, 10010) TNAME(IH), ((STEMS(IH, ID)/2.471044),
72     * |    ID = 1, NDIAM)
73      |    NUMLIN = NUMLIN + 1
74      | |
75      |    ++--ENDDO
76      +--ENDIF
77     RETURN
78     END
79
80 C ***** End of Subroutine PTSTBL; File name: PRNTSTBL.FOR *****
***** Subroutine RANDS(K, YFLO), file: RANDS.FOR *****
A portion of the: Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last revised by K. Sheehan January 1988; revised starting in 1989 by Colbert and Racin.
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Pseudo-random number generator;
called from subroutines TREE21 and TREE22.
No calls made to other routines.

** Local variables, parameters, and inputs required by Subroutine RANDS(K, YFLO) **
The following designations for LOCATIONs apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXN := CAPS or CAP$digit indicate a common block name

NAME - LOCATION - DESCRIPTION
-----------------------------------------------
FLM   1 - Floating point equivalent of integer seed M.
I     1 - Index used in modular extraction.
K     cp - Random number seed for this iteration.
M     n - Random number generator, large base for routine.
N     n - Random number generator, small base for routine.
YFLO  cp - Real output -- pseudo-random in [0.0,1.0].

SUBROUTINE RANDS(K, YFLO)

  DATA M, N, FLM/8192, 5, 8192./
  DO I = 1, 3
    K = MOD(N*K, M)
  ENDDO
  YFLO = FLOAT(K)/FLM
RETURN
END

***** End of Subroutine RANDS, file name: RANDS.FOR *****
***** Subroutine RELSTK, file: RELSTOCK.FOR *****

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(the stand submodel) converted to a stand-alone model. Last revised by K. Sheehan January 1988; revised starting in 1989
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Calc. relative stocking ('RSTOCK') based on GTR-NE-96 (Silvah);
sum the total number of stems by diam. class in the three stocking
groups identified in Silvah as TOT1, TOT2, & TOT3.
Called from the main program DAMSR.

No calls made by this routine.

** Local variables, parameters, and inputs required by Subroutine RELSTK **
The following designations for LOCATIONS apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) -XXN:= CAPS or CAPS+digit indicate a common block name

NAME - LOCATION - DESCRIPTION
-------------------------------------------------------------
DTAM(id) S1 Diameter class midpoint (cm)
DM 1 Diameter class midpoint (in)
ID 1 Diameter class index
IH 1 Host species index
ISTOKG(ih) S1 Stocking class for host ih
NDIAM S4 Number of diameter classes, constant = 20
NHOSTS GEN1 Number of hosts in simulation (less or eq. 6)
RSTOCK S3 Relative stocking number for stand
STEMS(ih,id) S1 Stems per ha in (host X diam) cell
STEM 1 Stems per acre, converted
STOCKS(ih,cf) S2 Stocking class (or) coefficients for quadratic equations (cf=1,2,3 for constant, linear, or
quadric term)
TOT1(id) 1 Total stem count across species for each
diameter class (id) and stocking class (1, 2,
or 3: as part of the variable name).

SUBROUTINE RELSTK

**** Include blocks ****

INCLUDE 'GEN1.CMB'
INCLUDE 'S1.CMB'
INCLUDE 'S2.CMB'
INCLUDE 'S3.CMB'
INCLUDE 'S4.CMB'
DIMENSION TOT1(20), TOT2(20), TOT3(20)

DO ID = 1, NDIAM
   TOT1(ID) = 0.0
   TOT2(ID) = 0.0
   TOT3(ID) = 0.0
ENDDO

RSTOCK = 0.0

DO ID = 1, NDIAM
   DO IH = 1, NHOSTS

Total stem counts for each of the three stocking classes and each diameter class. Change stems from per HA to per AC.

ISTOKG(ih)=stocking class for species ih (acc'ding to Silvah)

STEMT = STEMS(IH, ID)/2.471044

IF (ISTOKG(IH) .EQ. 1) TOT1(ID) = TOT1(ID) + STEMT
IF (ISTOKG(IH) .EQ. 2) TOT2(ID) = TOT2(ID) + STEMT
IF (ISTOKG(IH) .EQ. 3) TOT3(ID) = TOT3(ID) + STEMT

ENDO

Change diameter from cm to in. Calc. relative stocking based on Silvah's method (Marquis et al. 1984 - GTR-NE-96).

DM = DIAM(ID)/2.54
RSTOCK = RSTOCK + TOT1(ID) *(STOCKS(1, 1) + STOCKS(1, 2) * DM +
   STOCKS(1, 3) *(DM**2)) + TOT2(ID) *(STOCKS(2, 1) + STOCKS(2, 2) * DM +
   STOCKS(2, 3) *(DM**2)) + TOT3(ID) *(STOCKS(3, 1) + STOCKS(3, 2) * DM +
   STOCKS(3, 3) *(DM**2))

ENDO

RETURN

END

*** End of Subroutine RELSTK -- file name: RELSTOCK.FOR ***
****  Function SLIP(XX, X, Y, N), file: SLIP.FOR  ****
A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
revised by K. Sheehan January 1988; revised starting in 1989
by Colbert and Racin.
J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

Called two times by TREE22.
No routines called by this function.
Linear-interpolation function, created by
Jim Colbert, USDA-FS, Morgantown, WV 26505 USA
Input is XX; find YY(XX) by linear interpolation; (X(I),Y(I))
pairs are used for XX greater than X(1) and less than X(N);
c otherwise end value Y(I) or Y(N) is used.

** Local variables, parameters, and inputs required by Subroutine SLIP(XX, X, Y, N) **
The following designations for LOCATIONs apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XNN := CAPS or CAPS+digit indicate a common block name

----------------------------------------------
NAME - LOCATION - DESCRIPTION
----------------------------------------------
l - Index for (X,Y) pairs.
cp - Dimension of the call parameter arrays.
cp - Function return variable.
cp - Independent variable array.
cp - Independent variable for which dependent is to be associated [Y = SLIP(X)].
Y - Dependent variable array.

----------------------------------------------
FUNCTION SLIP(XX, X, Y, N)

DIMENSION X(N), Y(N)
+-IF (XX .LE. X(1)) THEN
  | SLIP = Y(1)
+-ELSEIF (XX .GE. X(N)) THEN
  | SLIP = Y(N)
+-ELSE
  | DO I = 1, N-1
  | I IF (XX .LE. X(I+1)) GOTO 100
  | ENDDO
  | RETURN
100 | SLIP = Y(I) + ((Y(I+1) - Y(I))/(X(I+1) - X(I)))*(XX - X(I))
+-ENDIF
RETURN
END
****  End of Function SLIP, file name: SLIP.FOR  ****
***** Subroutine THGHTS, file: THEIGHTS.FOR *****
A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(converted to a stand-alone model. Last revised by K. Sheehan January 1988; revised starting in 1989
by Colbert and Racine.
J. Colbert, Northeastern Forest Experiment Station
160 Canfield St., Morgantown, WV 26505 (304)-285-1600

Calculate heights (cm) for each host-diameter class (height).
Equation (2) in "A Description of the Stand-Damage Model"
If the diameter is greater than the max. diam for species (ih),
then set the height = the max. height for species ih.
Called by the main program DAMSR.
No calls made to other routines.

** Local variables, parameters, and inputs required by Subroutine THGHTS **
The following designations for LOCATIONS apply:
(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXN := CAPS or CAPS-digit indicates common block name

NAME LOCATION DESCRIPTION
B1(ih) S1 - Linear effect coefficient for diameter-height
B2(ih) S1 - Quadratic effect coefficient
DIAM(ih) S1 - Current diameter of the tree (by diam. class)
DMAX(ih) S1 - Maximum diameter of this species (ih).
HEIGHT S1 - Height of tree diameter class (id) for species (ih).
ID S1 - Maximum height for a tree of this species (ih).
NDIAM 1 - Diameter index (1, ..., NDIAM)
IH S4 - Species index (1, ..., NHOSTS)
NDIAM S4 - Number of diameter classes (20) for each species.

--- Subroutine THGHTS ---
***** Include blocks *****
INCLUDE 'GEN1.CMB'
INCLUDE 'S4.CMB'

Calculate height for each tree-class cell by species and diam.

*DO IH = 1, NHOSTS
| *DO ID = 1, NDIAM
| | HEIGHT(IH, ID) = 137.0 + (B1(IH)*DIAM(ID)) - (B2(IH)*DIAM(ID))**2
*| | (ID)**2)
56     IF (DIAM(ID) .GE. DMAX(IH)) HEIGHT(IH, ID) = HMAX(IH)
57         ENDDO
58     ENDDO
59     RETURN
60     END
61
c  *** End of Subroutine THGHTS; file name THEIGHTS.FOR  ***
1 c ***** Subroutine TINIT, file: TINIT.FOR *****
2 c A portion of the:
3 c Stand-Damage Model - a portion of the Gypsy Moth Life System Model
4 c (the stand submodel) converted to a stand-alone model. Last
5 c revised by K.Sheehan January 1988; revised starting in 1989
6 c by Colbert and Racin.
7 c
8 c J. Colbert, Northeastern Forest Experiment Station
9 c 180 Canfield St., Morgantown, WV 26505 (304)-285-1600
10 c
11 c Read parameter values & initial conditions for the stand submodel.
12 c Called by the main routine DAMSR.
13 c No calls made by this routine.
14 c
15 c ** Local variables, parameters, and inputs required
16 c by Subroutine TINIT **
17 c These following designations for LOCATIONs apply:
18 c (1) - l := local variable
19 c (2) - n := new parameter; not yet assigned to a common block
20 c (3) - cp := call parameter of this subroutine
21 c (4) - s := subroutine called from within this code
22 c (5) -XXN:= CAPS or CAPS+digit indicate a common block name
23 c
24 c NAME - LOCATION - DESCRIPTION
25 c
26 c ** AGE_MAX(ih) S1 - Maximum age (years) for species ih
27 c ** BDIE(ih) S1 - Base tree mortality rate
28 c ** B1 & B2(ih) S1 - Height coefficients for species ih
29 c ** COLD(ih) S2 - Minimum total degree-days per year that occur within
30 c the range of species ih
31 c ** CRWDMN S2 - Minimum value for crown in equation 12. see TREE21.
32 c ** CR1-CR4(ih) S1 - Live crown ratio parameters for species ih
33 c ** DEBUG LOG1 Logical variable, true for "DEBUG" output
34 c ** DFLC(i,j) S3 - For j=1,2;i=1,2: parameters for equation (13)
35 c ** (light) and equation (14) (heavy) for predicting
36 c ** DEFIND (eqn. (16)), the effect of current defolia-
37 c ** tion on diameter growth.
38 c ** DFOELDE S3 - Slope of the defoliation effect curve; and the
39 c maximum proportional decrease in this year's foliage
40 c ** production (at 100% defoliation) due to last year's
41 c ** defoliation (defl(ih,ih)) in treel.
42 c ** DIAM(id) S1 - Midpoint diameter of diameter class id
43 c ** DLEN(id) S1 - Range in diameters of trees in diameter class id
44 c ** DLENBASE S1 - The base diameter length for all diameter classes.
45 c ** note that to assure proper use of mortality and
46 c ** growth calculations, all diameter classes are now of
47 c ** equal width.
48 c ** DMAG(ih) S1 - Maximum diameter (cm) for species ih
49 c ** EPSIGR S2 - Decision parameter for including stems(host.diam) in
50 c ** growth calculations, if >0 then small stem counts
51 c ** will not enter into these calculations.
52 c ** EPSIMG(i) S4 - Decision parameters for management (tree removals).
53 c ** EPSITR S2 - Decision parameter for including stems(h,d) in
54 c ** transfer between diameter classes.
55 c ** FDIE S1 - Proportion of trees of species ih growing
56 c (ih, nf, isite) on site isite that die following nf consecutive
57 c years of heavy defoliation.
58 c F1, F2(ih) S1 - Parameters used to calculate foliage biomass for
59 c species ih.
60 c GROWR(ih) S1 - Base growth rate parameter for species ih
61 c HMAX(ih) S1 - Maximum height (cm) for species ih
62 c HOT(ih) S2 - Maximum total degree-days per year that occur within
63 c the range of species ih
64 c HOVER S2 - Ht. of overstory/understory boundary (cm or ft) if
65 c ibound=1; else = diam. of boundary (cm or in). will
66 c be converted to metric units if necessary.
67 c I 1 - Counter for loading (reading in) arrays
68 c IBOUND S4 - Overstory/understory boundary type: 1= ht, 2= diam
69 c ICAT S4 - Tree graphics category: 1= overstory, 2=understory,
70 c 3=total
71 c ID 1 - Diameter index
72 c IDEF 1 - Defoliation index for reading/writing FDIE.
73 c IDPOLY S3 - Calendar year for defoliation input.
74 c IDHIST S3 - Class variable, values 0, 1, 2, or 3 depending
75 c (ih, ia, iy) on percent defoliation last year (iy=1) and 2 years
76 c ago (iy=2) for a given host and strata. see TREE22
77 c for defoliation range definitions of this class
78 c of variable. is: the strata, 1 for overstory, 2 for
79 c understory; not defined for other strata (3 or 4).
80 c IH 1 - Host species index.
81 c IN 1 - Index for reading in Shade and Stocking effect
82 c values.
83 c IS 1 - Index for reading in Strata specific values of
84 c defoliation history (IDHIST).
85 c ISHADE S4 - Shade tolerance index (it = 1 := recruitment,
86 c (ih, it) = 2 := diam. growth).
87 c ISIT 1 - Site index for reading data.
88 c ISITE S4 - Index to site (1=wet, 2=medium, 3=dry)
89 c ISOPT S4 - Stress option: 0 no stress, 1 = stress occurs at
90 c random, 2 = stress occurs only for designated years.
91 c ISTOKG(ih) S1 - Rel. stocking index for each tree species (1,2,or 3)
92 c IY 1 - Year index for reading data.
93 c J 1 - Index for reading & writing STOCKS and DFLC values.
94 c JDB GEN1 - DEBUG file handle reference no.
95 c JDEF GEN1 - Defoliation data file handle reference no. (= 14)
96 c JSOUT1 GEN1 - = 13 = stand table (output) file handle ref. no.
97 c JSOUT2 GEN1 - = 15 = no. stems file handle reference no.
98 c JSOUT3 GEN1 - = 16 = basal area file handle reference no.
99 c JSOUT4 GEN1 - = 17 = volume file handle reference no.
100 c JSOUT5 GEN1 - = 18 = dbh file handle reference no.
101 c JTIN GEN1 - = 10 = tree data file (input) handle reference no.
102 c LDEFOLO LOG2 - Logical variable - true if defoliation is to be
103 c simulated.
104 c MANAGE S4 - Stand management options (0=none, 1=specific harvest
105 c rates, 2=target no. of stems)
106 c METRIC LOG2 - True if metric units are used for stand data (input)
107 c MTOTAL S4 - Total number of management actions (also no. of
108 c years that management will take place).
109 c MYEARS S4 - Years that management actions have been scheduled.
110 c NDIAM S4 - Number of diameter classes (20).
111 c NHOSTS  GEN1 - Number of host tree species in the current
112 c simulation, less than or equal to 6.
113 c NSTRPYR  S4 - Number of years with additional stress, under
114 c additional stress option isopt = 2, for defoliation
115 c induced stress mortality.
116 c PLOTAR  S3 - Sample Plot area (ha if metric = true, otherwise ac)
117 c PLOTSZ  S2 - The size of the plot to be used when calculating the
118 c shading multiplier for tree growth.
119 c FRTMIN  S2 - Set smallest residual stem counts to be printed in
120 c the stand table.
121 c RECRUT(ih)  S1 - Max. # of trees recruited to the smallest diameter
122 c class per year for species ih
123 c RESTIN  S1 - Number of larval resting sites per 100 sq-cm of
124 c (in. is)
125 c bole and branch surface area (for lower boles of
126 c overstory trees, is=1; for upper boles and branches
127 c of overstory trees and for all boles and branches of
128 c understory trees, is=2)
129 c RSMULT  S2 - Parameter for effect of relative stocking on tree
130 c growth.
131 c SGMORT  S2 - No. of years of slow growth (NSLOW) effect on tree
132 c mortality. Exponential rate coefficient for
133 c calculating G N T E R, eqn. (18).
134 c SHADMN  S1 - Minimum value for shade in equation 16.
135 c SHH1,SHY  S1 - Parameters for effect of light on diam growth, by
136 c mortality.
137 c SLOWD  S1 - Minimum growth (cm/yr) required to avoid add.
138 c STABLE  LOG2 - Logical, true if stand table output has been
139 c requested.
140 c STEMS(ih, id)  S1 - Number of stems of species ih in diameter class id.
141 c STNDAR  S3 - Stand area (ha if metric = true, otherwise ac)
142 c STOKS  S2 - For j=1,2,3;i=1,2,3: stocking class parameters, 3
143 c per quadratic, 3 stocking classes, species specific
144 c (in lstokg(ih)).
145 c STOKX  S1 - Parameters to adjust effect of relative stocking on
146 c STOKY  S1 - recruitment. Arrays [5,4].
147 c (ishade(ih,1,4))
148 c STRESS  S1 - The probability that a stand on site isite will not
149 c (isite)
150 c be subject to additional unspecified stress. Used
151 c in tree mortality calculations.
152 c STRPAC(i)  S1 - Additional mortality due to stress in years with
153 c heavy defoliation (1 = mort. without stress, 2 =
154 c mort. w/ stress).
155 c SURFAR(ih)  S1 - Biomass/surface area conversion constant for species
156 c ih.
157 c TEMPMN  S1 - Minimum value for TEMP in equation 11(b).
158 c TGBA  LOG2 - Logical variable, true to open Basal area data file.
159 c TGDH  LOG2 - Logical variable, true to open mean DHN data file.
160 c TGSTEM  LOG2 - Logical variable, true to open stem count data file.
161 c TVOL  LOG2 - Logical variable, true to open volume data file.
162 c TFLIGHT  S2 - Shading coefficient, equation (10).
163 c TNAME(ih)  CHAR1 Tree species code, two characters.
SUBROUTINE TINIT

FORMAT (/IX, I1, IX, L1, IX, L1)
FORMAT (1X, I4)
FORMAT (2(1X, F6.2), 1X, I1, 1X, F7.1)
FORMAT (" PLOTAR = ", F7.3)
FORMAT (" STNDAR = ", F7.3)
FORMAT (/). F4.1. 1X. F7.5/8(61X, F6.2)/. 2(1X, F5.2), 1X,
F7.4.1X, /, 1X, L2, 3(1X, F4.1), /1X, F7.4, 4(/, 6(1X, F4.0)),
4(/, 6(1X, F5.2))
FORMAT (3(31X, F10.7), /), 4(1X, F4.2), 1X, F6.3, /, 4(1X,
F11.8))
FORMAT (5X, 'STOCKS(t,J) array', /,'i=', 3(5X, I1, 6X)/, 'I=I',
3(310.7, 1X)/, 'I=I', 3(310.7, 1X)/, 'I=I', 3(310.7, 1X)/,
', 'DPOLDR CWDMDN SHADMN TEMPMN SGMORT', /, 4(2X,F4.2,2X),
'I=I', 2(1X, F10.8), /, 'I=I', 2(1X, F10.8)
FORMAT (1X, I3, 1X, F6.2, 1X, I1, /, 6(1X, F8.6))
FORMAT (' TINIT, AT READ 1240: NSTRYR=', I3, ', DLENBASE=', F6.2,
', 'ICAT=', I1, ', EPSIGN=', F8.6, ', EPSITR=', F8.6, ', PRTMIN=',
', F8.6, ', 'EPSIMG(I), I=I, 3(1X, F8.6))
FORMAT (A/2, 2(1X, I2), 2(1X, F8.4), 1X, F7.1, 2(1X, F6.0), 1X,
F6.3, /, 1X, F6.2, 1X, F7.1, F4.1, 1X, F6.3, /, 1X, F7.1,
1X, F7.0, 1X, F4.0, 2(1X, F8.5), 1X, F6.1, 1X, I2, 1X, F6.0, /
9(1X, F4.2), /, 4(1X, I4))
FORMAT (10(1X, F6.1), /, 10(1X, F6.1))
FORMAT (/, I2)
FORMAT (1X, I4, 1X, I1)

Include the common blocks:

INCLUDE 'CHAR1.CMB'
INCLUDE 'GEN1.CMB'
INCLUDE 'LOG1.CMB'
INCLUDE 'LOG2.CMB'
INCLUDE 'S1.CMB'
INCLUDE 'S2.CMB'
INCLUDE 'S3.CMB'
INCLUDE 'S4.CMB'
INCLUDE 'WTHR1.CMB'

End of common block includes

READ (JTN, 10000) ISITE, METRIC, LDEPOL
IF (DEBUG) WRITE (JDB, 10000) ISITE, METRIC, LDEPOL

If requested or if debug trace is on, open Stand Table Output file.

IF (STABLE .OR. DEBUG) OPEN (13, FILE = 'STANDBL.D1S', STATUS =
* 'UNKNOWN'
JSOUT1 = 13
+-IF (LDEFOL) THEN
  OPEN (14, FILE = 'DEFOLDAT.D1S', STATUS = 'OLD')
  JDEFF = 14
  READ (JDEFF, 10010) IDFOLY
+-ENDIF
IF (TGSTEM) OPEN(15, FILE = 'GSTEMNUM.D1S', STATUS = 'UNKNOWN')
JSOUT2 = 15
IF (TGBA) OPEN (16, FILE = 'GBASALAR.D1S', STATUS = 'UNKNOWN')
JSOUT3 = 16
IF (TVGOL) OPEN (17, FILE = 'GVOLUME.D1S', STATUS = 'UNKNOWN')
JSOUT4 = 17
IF (TODYB) OPEN (18, FILE = 'GDBH.D1S', STATUS = 'UNKNOWN')
JSOUT5 = 18
READ (JTIN, 10020) PLOTAR, STNDAR, IBOUND, HOVER

c Check to see that plot and stand areas are big enough.
+-IF ((PLOTAR .LT. 0.01) .OR. (STNDAR .LT. 0.01)) THEN
  WRITE (*, *) ' Error, plot or stand area too small.'
  WRITE (*, 10030) PLOTAR
  WRITE (*, 10040) STNDAR
+-ENDIF

c Read miscellaneous parameters for stand model.
READ (JTIN, 10050) TLIGHT, TKL, ((SHX(I, IN), I = 1, 6), IN= 1,
  4), ((SHY(I, IN), I = 1, 6), IN = 1, 4), STRPAC1, STRPAC2,
  4), PLOTSZ, ISOPT, (STRESS(ISIT), ISIT = 1, 3), RSMULT, ((STOKX(I,
  IN), I = 1, 6), IN = 1, 4), ((STOKY(I, IN), I = 1, 6), IN = 1,
  4)

Within the interface, units are English for all variables with units,
convert to metric for use within the model.
PLOTAR = PLOTAR * 0.404687
STNDAR = STNDAR * 0.404687
PLOTSZ = PLOTSZ * 0.404687

For variable HOVER, convert diameter or height to metric
30.48 cm/ft or 2.54 cm/in, depending upon the type boundary
chosen by user.
+-IF (IBOUND .EQ. 1) HOVER = HOVER*30.48012
+-IF (IBOUND .EQ. 2) HOVER = HOVER*2.54001

READ (JTIN, 10060) ((STOCKS(I, J), J = 1, 3), I = 1, 3), DPOFOLDE,
  * CROMDN, SHADMN, TEMPAN, SGMORT, ((DFLC(I, J),J = 1, 2), I=1,2)
READ (JTIN, 10080) NSTRYR, DLENBASE, ICAT, EPSIGR, EPSITR,
       * (EPSIMG(I), I = 1, 3), PRTMIN
       IF (DEBUG) THEN
       WRITE (JDB, 10090) NSTRYR, DLENBASE, ICAT, EPSIGR, EPSITR,
       * PRTMIN, (EPSIMG(I), I = 1, 3)
       WRITE (JDB, 10070) (J, J = 1, 3), ((STOCKS(I, J), J = 1, 3), I,
       * ((DFL(I, J), J = 1, 2), I = 1, 2)
       +--ENDIF

c Convert diameter base to metric units:
DLENBASE = DLENBASE*2.54001
DO ID = 1, 20
   DLEN(ID) = DLENBASE
   DIAM(ID) = DLENBASE*FLOAT(ID) - DLENBASE/2.0
+--ENDDO

c **************************************
c Read info. for each tree species.
c **************************************
DO IH = 1, NHOSTS
   READ (JTIN, 10100) TNAME(IH), ISHADE(IH, 1), ISHADE(IH, 2),
   * RESTIN(IH, 1), RESTIN(IH, 2), GROWR(IH), HOT(IH),
   SLOWD(IH), CR1(IH), CR2(IH), CR3(IH), CR4(IH), DMAX(IH), HMAX
   * (IH), AGEMAX(IH), F1(IH), F2(IH), SURFAR(IH), ISTOKG(IH),
   * RECRUT(IH), ((FDIE(IH, IDEF, ISIT), IDEF = 1, 3), ISIT = 1,
   * 3), ((IDHIST(IH, IS, IY), IS = 1, 2), IY = 1, 2)
   IF (DEBUG) WRITE (JDB, 10100) TNAME(IH), ISHADE(IH, 1), ISHADE
   * (IH, 2), RESTIN(IH, 1), RESTIN(IH, 2), GROWR(IH), HOT(IH),
   SLOWD(IH), CR1(IH), CR2(IH), CR3(IH), CR4(IH), DMAX
   * (IH), HMAX(IH), AGEMAX(IH), F1(IH), F2(IH), SURFAR(IH),
   * ISTOKG(IH), RECRUT(IH), ((FDIE(IH, IDEF, ISIT), IDEF = 1, 3),
   * ISIT = 1, 3), ((IDHIST(IH, IS, IY), IS = 1, 2), IY = 1, 2)
   IF (IH, 2), RESTIN(IH, 1), RESTIN(IH, 2), GROWR(IH),
   * HOT(IH), SLOWD(IH), CR1(IH), CR2(IH), CR3(IH), CR4(IH),
   DMAX(IH), HMAX(IH), AGEMAX(IH), F1(IH), F2(IH), SURFAR(IH),
   * ISTOKG(IH), RECRUT(IH), ((FDIE(IH, IDEF, ISIT), IDEF = 1, 3),
   * ISIT = 1, 3), ((IDHIST(IH, IS, IY), IS = 1, 2), IY = 1, 2)
   c Convert SURFAR, SLOWD, DMAX, HMAX, and RECRUT to metric units:
   1 sq.-in. / oz. = 0.22757 sq.-cm / g.
   1 in. == 2.54001 cm.
   1 ft. == 30.48012 cm.
   1 acre == 2.471044 acres
   SURFAR(IH) = SURFAR(IH)*0.22757
   SLOWD(IH) = SLOWD(IH)*2.54001
   HMAX(IH) = HMAX(IH)*30.48012
   DMAX(IH) = DMAX(IH)*2.54001
   RECRUT(IH) = RECRUT(IH)*2.471044
   c Computing the parameters B1(ih) & B2(ih).
   B1(IH) = 2.0*(HMAX(IH) - 137.0)/DMAX(IH)
   B2(IH) = (HMAX(IH) - 137.0)/(DMAX(IH)*DMAX(IH))
c Read the initial stocking levels for the stand.
| READ (JTIN, 10110) (STEMS(IH, ID), ID = 1, NDIAM)
| +-- ENDDO

338 c Convert stems from stems/plot-area to stems/ha. Conversion
339 c from trees/ac. to trees/ha. is handled along with the plot area
340 c since plot area has already been converted to hectares.
| +-- DO IH = 1, NHOSTS
342 | | +-- DO ID = 1, NDIAM
343 | | | STEMS(IH, ID) = (STEMS(IH, ID)/PLOTAR)
344 | | +-- ENDDO
345 | +-- ENDDO

348 c Calculate the base mortality rate for each species as a
349 c function of the maximum age for that species (from Rotkin
350 c and others 1972).
| +-- DO IH = 1, NHOSTS
352 | | BDIE(IH) = 4.0/(AGEMAX(IH) + .000001)
354 | +-- ENDDO

357 c Note that the variables MYEARS and MANAGE are read once each time
358 c MTOTAL is decremented; the associated management data are read
359 c elsewhere. These reads take place in the subroutine TREE21. JTIN is
360 c closed at the end of main routine DAMAGE (or Subroutine DAMSR when run
361 c under control of the front end).
| READ (JTIN, 10120) MTOTAL
364 | +-- IF (MTOTAL .GT. 0) THEN
365 | | READ (JTIN, 10130) MYEARS, MANAGE
366 | +-- ENDF
367 RETURN
368 END
369
370 c *** End of Subroutine TINIT -- File TINIT.FOR ***
***** Subroutine TPRINT, file: TPRINT.FOR *****
A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
by Colbert and Racin.
J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

Write Stand Table Output summary for one year.
Called from the main program DAMSR.
No calls made by this to other routines.

** Local variables, parameters, and inputs required
by Subroutine TPRINT() **
The following designations for LOCATIONs apply:
(1) - i := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XNN := CAPS or CAPS+digit indicate a common block name

NAME - LOCATION - DESCRIPTION
-----------------------------------
ACTPOL S3  - Actual foliage present (after defoliation).
ANNDD(100) WTHR1 - Annual total day-degrees for year IYEAR.
CROWD S2  - Crowding index (a tree growth modifier).
DEPSTN S2  - Defoliation index (a tree growth modifier).
DEFL S3  - Percent defoliation, by host and strata.
DMEAN S2  - Mean diameter, by host and strata.
IY S1  - Host species number.
IS S1  - Strata number.
ISYEAR GEN1 - Starting year, example: 1987. Then incremented to
contain calendar year of simulation.
IYEAR GEN1 - Year index, used for array indexing.
JSOUT1 GEN1 - Number of file: stand output.
METRIC LOG2 - Set to true if input/output units are to be metric
NHOSTS GEN1 - Number of hosts to be simulated.
NUMLIN GEN1 - Line counter for tabular output.
PRTMIN S2  - Minimum amount of stems to get output printed.
RSTRES S2  - Proportion of mortality due to stress, by host.
SMFDEIE S2  - Mean tree mortality due to defoliation, by host
and strata.
SMGDEIE S2  - Mean tree mortality due to slow growth.
SMGROW S2  - Mean actual diameter growth.
SMGRO S2  - Mean potential diameter growth.
SMSHAD S2  - Mean shading growth modifier.
SMTDIE S2  - Mean total tree mortality.
STEM S2  - Number of stems, by host and strata.
STRATA 1 - Names of the 4 strata simulated for each host.
TEMP S2  - Tree growth modifier for temperature, by host.
TNAME 1 - Tree code, by host.
VOL S2  - Stand volume, by host and strata.
YLD S2  - Yield from harvesting, by host and strata.
SUBROUTINE TPRINT

FORMAT (10X, 'SOURCES OF MORTALITY'/, 79X, 'MODIFIERS OF ',
  60 'GROWTH', 9X, 23(' -'/), 77X, 23(' -'), ' TOTAL BASE SLOW',
  61 ' RAND. GYPSY'/, 14X, ' % ', 4X, ' BASAL NUMBER MEAN ', 26X,
  62 ' ACTUAL POTEN. GYPSY', 7X, ' STAND ', 9X, ' % ', 5X, ' % GR.',
  63 ' STRESS MOTH')

10010 FORMAT (1X, 'SPEC STRAT DEFOL AREA STEMS DBH VOLUME',
  65 ' YIELD FOLIAGE GROWTH GROWTH MOTH TEMP DENS. SHADE',
  66 ' MORT. MORT. MORT. MORT. MORT. ')

10020 FORMAT (17X, (FT2/AC) (AC) (IN) (FT3/AC) (LB/AC)',
  68 (IN) (IN)'/1X, 130(' -'))

  70 (CM) (CM)'/1X, 130(' -'))

10040 FORMAT (1X, 10X, 100(' -'))/1X, T20, 'End of Year: ', I4, T60,
  72 'Accumulated day-degrees for year: ', F8.1/

10050 FORMAT (1X, A4, 1X, A5, 1X, F5.0, 1X, F6.1, 1X, F6.1, 1X, F5.1,
  74 1X, F7.1, 2X, F7.1, F8.1, 1X, F6.3, 1X, F6.3, 4 (1X, F5.3), 5 (1X,
  75 1X)

10060 FORMAT (1X)

INCLUDE 'CHAR1.CMB'

INCLUDE 'GEN1.CMB'

INCLUDE 'LOG2.CMB'

INCLUDE 'S1.CMB'

INCLUDE 'S2.CMB'

INCLUDE 'S3.CMB'

INCLUDE 'WTHRL.CMB'

c Write header info. if needed.

c Formats for output headers (10030= for metric, 10020= for English).

+--IF (NUMLIN .GT. 60) THEN
  | WRITE (JSOUT1, 'A1') 'f C
  |
  | WRITE (JSOUT1, 10000)
  | WRITE (JSOUT1, 10010)
  | +--IF (METRIC) THEN
  | WRITE (JSOUT1, 10030)
  | +--ELSE
  | WRITE (JSOUT1, 10020)
  | +--ENDIF
  | NUMLIN = 10
  | +--ENDIF

PRINT header for start of year.

+--IF (METRIC) THEN
  | WRITE (JSOUT1, 10040) ISYEAR, ANNNDD(IYEAR)/1.8
  | +--ELSE
  | WRITE (JSOUT1, 10040) ISYEAR, ANNNDD(IYEAR)
```fortran
111  +---ENDIF
112    NUMLIN = NUMLIN + 5
113
114 c For each host & strata, print output if there are stems.
115 c Convert foliage biomass from g to kg & mortality proportions
116 c to percentages.
117
118  +---DO IH = 1, NHOSTS
119   |  +---DO IS = 1, 2
120   |    IF ((STEM(IH, IS) .GT. PRTMIN) .OR. (YLD(IH, IS) .GT. 0.0))
121      +---THEN
122      |      WRITE (JSOUT1, 10050) TNAME(IH), STRATA(IS), DEFL(IH,
123      |          IS), BA(IH, IS), STEM(IH, IS), DMEAN(IH, IS), VOL(IH,
124      |          IS), YLD(IH, IS), ACTFOL(IH, IS)/1000.0, SMGROW(IH, IS)
125      |      SMPGRO(IH, IS), DEFIND(IH, IS), TEMP(IH), CKWUD,
126      |      SMOHAD(IH, IS), SMTDIE(IH, IS)*100.0, BDIE(IH)*100.0,
127      |      SMGDIE(IH, IS)*100.0, RSTRES(IH, IS)*100.0, SMFDIE(IH,
128      |          IS)*100.0
129      |      NUMLIN = NUMLIN + 1
130      |      +---ENDIF
131    +---ENDDO
132    WRITE (JSOUT1, 10060)
133     NUMLIN = NUMLIN + 1
134
135 c Go to next page & print header if necessary. NUMLIN = no. of lines
136 c printed on the page so far; go to a new page when NUMLIN > 60
137
138  +---IF (NUMLIN .GT. 60 .AND. IH .NE. NHOSTS) THEN
139      |     WRITE (JSOUT1,'(A1)') '\"f\c'
140      |  +---IF (MTRT?) THEN
141      |     WRITE (JSOUT1, 10000)
142      |  +---ELSE
143      |     WRITE (JSOUT1, 10010)
144      |     +---ENDIF
145      |     NUMLIN = 10
146      |  +---ENDIF
147     +---ENDDO
148    RETURN
149  END
150
151 c ***** End of subroutine TPRINT; File name: TPRINT.FOR *****
```
***** Subroutine TREE1, file: TREE1.FOR  *****

A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodule) converted to a stand alone model. Last
revised by K. Sheehan January 1988; revised starting in 1989
by Colbert and Racin.

J. Colbert, Northeastern Forest Experiment Station
180 Cantfield St., Morgantown, WV 26505 (304)-285-1600

This portion of the Stand-Damage Model calculates: foliage amounts,
crown ratios, no. of resting sites, as well as stem counts and basal
area in the under- and overstory strata by tree species.
Called form the main program DAMSR.
No calls made by this routine.

** Local variables, parameters, and inputs required
by Subroutine TREE1() **
The following designations for LOCATIONS apply:

(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXN := CAPS or CAPS+digit indicate a common block name

NAME - LOCATION - DESCRIPTION

CROWN 1 - Crown ratio for trees of particular species,
diameter, and height.
CR1 S1 - Crown ratio prediction equation coefficient 1.
CR2 S1 - Crown ratio prediction equation coefficient 2.
CR3 S1 - Crown ratio prediction equation coefficient 3.
CR4 S1 - Crown ratio prediction equation coefficient 4.
DEBUG LOG1 - Logical variable, true to produce debug output.
DIAM S1 - Midpoint diameter of tree class (20 total).
DIAMTN S1 - Diameter converted to inches.
FOL S3 - Foliage biomass of strata (overstory or understory),
canopy leaf biomass.
POLL S1 - Pollen production
POLLN S1 - Pollen amount
POLLN1 S1 - Pollen amount
FOLIAG 1 - Intermediate value for individual host and diameter
FOLIAGE 1 - Foliage amount
FOLIAGE 1 - Foliage biomass
FOLIAGE 1 - Foliage biomass
FOLIAGE 1 - Foliage biomass
HEIGHT S1 - Height of each diameter class, by species.
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HEIGHT S1 - Height of each diameter class, by species.
HEIGHT S1 - Height of each diameter class, by species.
56 c OVERBA S3 - Basal area for the overstory by species.
57 c OVERS S3 - No. of stems in the overstory by species.
58 c R 1 - tree radius
59 c RESTIN S1 - The number of resting sites per square meter
60 c of surface area
61 c RSITES S3 - RSITES=number of resting sites.
62 c STEMS S1 - number of stems, by host and diameter class
63 c TOTOVER 1 - Total no. of overstory stems in stand.
64 c UNDBA S3 - understory basal area, by host
65 c UNDERS S3 - understory number of stems, by host
66 c WLEAF 1 - Total leaf area for the stand.
67 c X 1 - portion of equation calculation
68 c ---------------------------------------
69 c **SUBROUTINE TREE1**
70 10000 FORMAT (' In Subroutine TREE1: ',
71  * 'Stand basal area calculated, BAR = ', F10.5)
72 10010 FORMAT (' For IH = ', I2, ',', and ID = ', I2, ',', CROWN = ',',
73  * F10.5)
74 75 c **** Include blocks *****
76 77 INCLUDE 'GEN1.CMB'
78 INCLUDE 'LOGL.CMB'
79 INCLUDE 'S1.CMB'
80 INCLUDE 'S2.CMB'
81 INCLUDE 'S3.CMB'
82 INCLUDE 'S4.CMB'
83 84 85 c Set the following variables to zero:
86 c FOL=foliage biomass, RSITES=number of resting sites,
87 c OVERS & UNDERS = no. of stems in the overstory & understory
88 c OVERBA & UNDBA = basal area for the overstory & understory
89 90 101 c Sum total basal area for the stand (BAR) - used when calc. live
91 c crown ratio for individual trees. when finished, convert BAR
92 c from cm2/ha to ft2/ac
93 94 95 c ----------------------
96 97 98 99 100 101 102 103 104 105 106 107 108 109 110
| 111 | BAR = BAR + STEMS(IH, ID)*3.14159*R*R
| 112 | +---ENDDO
| 113 | +---ENDDO
| 114 |
| 115 | c convert from sq.-cm/ha to sq.-ft./ac.
| 116 |
| 117 | BAR = BAR*0.000435609
| 118 |
| 119 | IF (DEBUG) WRITE (JDB, 10000) BAR
| 120 |
| 121 | c Calc. crown ratio for each tree based on Holdaway (1986). CR1- CR4 = parameters from Holdaway (1986). Crown ratio will be used when partitioning the resting sites on overstory trees between boles and crown. Convert diam. from cm to inches. Holdaway computed CRC (Crown Ration Code) from field data that was coded as 1 for crown ratios between 1 and 10 percent, 2 for ratios between 11 and 20 percent, etc. Thus we multiply by 0.1 and subtract 0.05 to get CRCRN.
| 122 |
| 123 | TOTOV = 0.0
| 124 | WLEAF = 0.0
| 125 | +---DO IH = 1, NHOSTS
| 126 | +---DO ID = 1, NDIM
| 127 | DIAMN = DIAM(ID)/2.54
| 128 | CRN = CR1(IH)/((1.0+CR2(IH)*BAR) + CR3(IH)*(1.0-EXP(-CR4(IH)*DIAMN)))*0.1-0.05
| 129 | |
| 130 | |
| 131 | IF (DEBUG) WRITE (JDB, 10010) IH, ID, CRN
| 132 |
| 133 |
| 134 | c Sum the total foliage in the stand (WLEAF, in kg per ha). F1 & F2 are allometric foliage biomass parameters from cSheehan (unpubl.).
| 135 |
| 136 | +---IF (STEMS(IH, ID) GT 0.0) THEN
| 137 | FOLIAG = F1(IH)*DIAM(ID)**(F2(IH)*STEMS(IH, ID)
| 138 | WLEAF = WLEAF + FOLIAG
| 139 |
| 140 | |
| 141 | c Separate overstory and understory calculations.
| 142 | c Set IS = to strata (1=overstory, 2=understory)
| 143 | c If height is to be used to separate over & understory.
| 144 | c or 2 if diameter is to be used. HOVER = the boundary ht. or diam.
| 145 |
| 146 | |
| 147 | |
| 148 | IS = 1
| 149 | +---IF (IBOUND .EQ. 1) THEN
| 150 | IF (HEIGHT(IH, ID) LT HOVER) IS = 2
| 151 | +---ELSE
| 152 | |
| 153 | |
| 154 | c Convert to g/ha & store understory foliage (FOL(ih,2)).
| 155 | c Sum the number of understory trees by species in UNDERS(ih).
| 156 |
| 157 |
| 158 | c Sum the basal area of understory trees by species in UNDBA(ih).
| 159 |
| 160 | c The number of resting sites (RSITES) is assumed to be a function of tree surface area and a species-specific index. Tree surface area is calculated by assuming that the tree is a right circular
166 c cone.  RESTIN(ih.ix) is the number of resting sites per square meter
167 c of surface area; therefore divide by 100**2=10000 to compute the
168 c number that will rest in location ix (ix = 1 for boles of overstory
169 c trees, ix = 2 for crowns of over- or understory trees).
170 | |
171 | |
172 |
173 | |
174 | |
175 |
176 |
177 |
178 |
179 |
180 |
181 |
182 c Next, for overstory trees:  sum foliage biomass in g/ha (FOL),
183 c no. of overstory stems (OVERS), & overstory basal area (OVERBA)
184 |
185 |
186 |
187 |
188 |
189 |
190 c For overstory trees, the lower bole is assumed to have the
191 c shape of a cylinder, and the upper bole is assumed to have the
192 c shape of a right circular cone.  CROWN = crown ratio (proportion
193 c of total tree height that is covered by live crown), and
194 c bole length = 1.0 - CROWN;  RESTIN(ih,1) is for boles of trees;
195 c RESTIN(ih,2) is for branches within crowns.  These (RESTIN) are
196 c numbers of resting sites per 100 cm. square area.
197 |
198 |
199 *
200 *
201 *
202 *
203 *
204 *
205 *
206 *
207 *
208 *
209 |
210 |
211 |
212 c *** End of subroutine TREE1; file name TREE1.FOR ***
***** Subroutine TREE21, file: TREE21.FOR *****

A portion of the
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
revised by K.Sheehan January 1988; revised starting in 1989
by Colbert and Racim.

J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

This routine (1) calculates the superior leaf area for each tree
class, (2) set crowding factor for this year, (3) sets stress option
ISTRES for this year, (4) reads the management prescription data for
this year (if any), and (5) sets up DEBUG output printing.

Called from main program DAMSR.
Calls subroutines RANDS and PTSTBL if conditions are met.

** Local variables, parameters, and inputs required
by Subroutine TREE21() **

The following designations for LOCATIONS apply:

(1) - l := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXX := CAPS or CAPS+digit indicate a common block name

NAME - LOCATION - DESCRIPTION

-----------------------------
CUTMAX S4 - Maximum diameter to be cut, by host & year.
CUTMIN S4 - Minimum diameter to be cut, by host & year.
CUTFR S4 - Proportion to be cut by species.
DEBUO LOG1 - True if debug table to be produced.
DEFL S3 - Percent defoliation, by host & strata.
DIAM S1 - Diameter at mid-point, by diameter class.
EPSIMG S4 - Min. no. of stems that must be present for a
particular cell stem count to be accumulated.
EPSI01 n - Minimum stem count (STEMS) required for use in calc-
ulation of superior leaf area and foliage biomass.
FAREA 1 - Accumulates foliage surface area.
FOLIAG 1 - Amount of foliage biomass for a given tree.
F1 S1 - Parameter for calculating foliage biomass /tree.
F2 S1 - Parameter for calculating foliage biomass /tree.
GTCRWD S - Tree heights by host and diameter class.
HEIGHT S1 - Height or diameter that separates overstory and
understory trees.
HTALL 1 - Height of tallest tree.
IBOUND S4 - Overstory/understory boundary type: 1 = height (ft
or cm), 2=diam. (in or cm).
ID 1 - Diameter index.
IH 1 - Host index.
IHOST 1 - Species of the tallest tree.
ISEED GEN1 - Random number seeds: 1=recruitment of new trees,
2-not used at this time, 3=additional tree
mortality due to stress, 4=add. gypsy moth
56 c     mortality due to winter temp., 5=for weather
57 c     generation, 6= GM L1 disp.
58 c ISITE  S4 - Index for site (1=moist, 2=intermediate, 3=dry).
59 c ISOPT  S4 - Tree stress option (1=stress occurs in random
60 c     years, 2=user specified stress years).
61 c ISTRAT  1 - Strata (1=over-, 2=understory).
62 c ISTRESS  1 - Stress index (1 = no stress this year, 2 = stress
63 c     will occur this year).
64 c ISTRYR  S4 - Used to decide when to add stress STRFAC(2) as SDIE
65 c IGRFAR  GEN1 - Start in year.
66 c JSOUT1  GEN1 - File number: stand output.
67 c JSTRS  GEN1 - File number: stress years.
68 c JTIN  GEN1 - File number.
69 c MANAGE  S4 - Stand management option: 0 = no actions, 1= user
70 c     specifies proportions to be cut, 2= user specifies
71 c     target no. of stems.
72 c MYEARS  S4 - Yrs that management actions have been scheduled.
73 c NDIAM  S4 - Number of diameter classes to be simulated.
74 c NTALL  1 - Pointer to tallest diameter class present.
75 c NHOSTS  GEN1 - Number of hosts to be simulated.
76 c NSTRYR  S4 - Number of stress years.
77 c PCUT  S4 - Number of trees to be cut, by host and year.
78 c PLOTSZ  S2 - Area for calculating influence of surrounding trees
79 c     on shading of a given tree.
80 c PTSTBL  s
81 c RANDS  s
82 c STABLE  LOG2 - True if stand submodel output is desired.
83 c STEMS  S1 - Number of stems, by host and diameter class.
84 c STRESS  S1 - Probability that a stand on site ISITE will not be
85 c     subject to additional unspecified stress.
86 c SUM  1 - Total stems.
87 c SUMLFA  S2 - Sum of leaf surface area for all trees taller than
88 c     a given tree, by host and diameter class.
89 c SURFAR  S1 - Foliage biomass to surface area conversion factor.
90 c TARGET  S4 - Target no. of residual stems (if MANAGE=2) for
91 c     scheduled harvests, by yr and host.
92 c TOBCUT  S4 - Total no. of stems to be harvested.
93 c TSUMDC  1 - Number of stems in the harvest range.
94 c X  1 - Value returned from random number generator.
95 c  
96 c ---------------------------------------------------------
97 c SUBROUTINE TREE21
98 10000  FORMAT (1X, I4)
99 10010  FORMAT (2(1X, F6.1), 1X, F6.2)
100 10020  FORMAT (2X, 'Initial Number of Stems per Hectare:', /, D6.1, /)
101 10025  FORMAT (2X, 'DIAMETER CLASS (cm.)'/2X, 'SPECIES', 20F6.2/, 2X, 7('--'), 20(102 10026  * '-----'))
103 c ***** Common Blocks Included:
104 c INCLUDE 'GEN1.CMB'
105 c INCLUDE 'LOG1.CMB'
106 c INCLUDE 'LOG2.CMB'
107 c INCLUDE 'S1.CMB'
108 c INCLUDE 'S1.CMB'
111  INCLUDE 'S3.CMB'
112  INCLUDE 'S4.CMB'
113  DIMENSION NDTALL(6)
114  c For each host species and diameter class, calculate the
115  c superior leaf area (SMLFA) -- the surface area of foliage
116  c on all trees taller than the given tree. Start with the tallest
117  c tree in the stand and work towards the shortest, accumulating
118  c foliage area and storing the superior leaf area for all taller
119  c trees (= FAREA for a grown trees) in SUMLFA.
120  c First set NDTALL(ih) to the index of the largest diameter
121  c class present for each tree species. Note that this is done for all
122  c trees with sufficiently positive stem counts. This assures that
123  c trees with only roundoff error for input height are ignored.
124  c Along the way, set SUMLFA and FAREA to zero.
125  c (1)*****************************************************************************
126  c ***
127  c EPSI01 = 0.0001
128  c
129  FAREA = 0.0
130  +---DO IH = 1, NHOSTS
131       |  NDTALL(IH) = 0
132       |  +---DO ID = 1, NDIA
133       |  |  SUMLFA(IH, ID) = 0.0
134       |  +---ENDDO
135       |  +---DO ID = NDIA, 1, -1
136       |  |  +---IF (STEMS(IH, ID) .GT. EPSI01) THEN
137       |  |  |  +---IF (ID .GT. NDTALL(IH)) NDTALL(IH) = ID
138       |  |  +---ENDIF
139       |  +---ENDDO
140       +---ENDDO
141  c For each sp., NDTALL now contains the diameter class index of the
142  c tallest trees. Compare the heights of the tallest trees for each host
143  c species. Set IHOST to the species of the tallest tree. The DO WHILE
144  c (.TRUE.) starts of the loop for ordering the trees from tallest to
145  c smallest.
146  c +---DO WHILE (.TRUE.)
147       |  HTALL = 0.0
148       |  IHOST = 0
149       |  +---DO IH = 1, NHOSTS
150       |  |  +---IF (NDTALL(IH) .GT. 0) THEN
151       |  |  |  +---IF (HTALL .LT. HEIGHT(IH, NDTALL(IH))) THEN
152       |  |  |  |  HTALL = HEIGHT(IH, NDTALL(IH))
153       |  |  |  IHOST = IH
154       |  |  +---ENDIF
155       |  +---ENDDO
156       +---ENDDO
157  c The species & diam. class of the tallest tree remaining
158  c are IHOST & NDTALL(IHOST).
159  c Check to see if no more trees are left; if so, then skip to
160  c next section of code. Label "100" is the exit point for this loop.
166       IF (IHOST .EQ. 0) GOTO 100
167
168       c Store foliage area accumulated so far (FAREA) in SUMFLA for the
169       c current tree, but adjust the area that the tree effects (PLOTSZ)
170       c this assumes that the affected area is similar to the stand at large,
171       c i.e., the stand is homogeneously stocked.
172
173       SUMFLA(IHOST, NDTALL(IHOST)) = FAREA*PLOTSZ
174
175       c Calculate the foliage area for the current tree and add the area per
176       c hectare to variable FAREA.  FOLIAG = foliage surface area of crown for
177       c tree, given no defoliation.  ISTRAT = strata (1=over-, 2=understory)
178       c DEFL = tree's total defoliation by species & strata this year.
179       c Determine if current tree is over or understory using IBOUND (1 = use
180       c hts, (2 = use diam.s) and HOVER (boundary ht. or diam.).  F1 & F2 =
181       c foliage biomass parameters from Sheehan (unpubl.) (for calc. kg).
182       c SURFA = leaf surface area to biomass ratio (cm2/g).  SURFA * .10 =
183       c m2/Kg.
184       ISTRAT = 1
185       IF (IBOUND .EQ. 1) THEN
186         IF (HEIGHT(IHOST, NDTALL(IHOST)) .LT. HOVER) ISTRAT = 2
187       ELSE
188         IF (DIAM(NDTALL(IHOST)) .LT. HOVER) ISTRAT = 2
189       ENDIF
190
191       FOLIAG = (F1(IHOST)*DIAM(NDTALL(IHOST))**F2(IHOST))*SURFA
192       FAREA = FAREA + (FOLIAG*(1.0 - (DEFL(IHOST, ISTRAT)/100.0))
193
194       c For the tree species that was just handled, reset the pointer
195       c NDTALL to the next smaller diameter class that has trees.
196
197       DO WHILE (.TRUE.)
198         NDTALL(IHOST) = NDTALL(IHOST) - 1
199         IF (NDTALL(IHOST) .EQ. 0) GOTO 90
200       ENDIF
201
202       IF (STEMS(IHOST, NDTALL(IHOST)) .GT. EPS101) GOTO 90
203
204       c Go back and find the next tallest tree.
205
206       ENDDO
207
208       CONTINUE
209       ENDDO
210
211       c Exit for the loop that started 60 lines up.
212
213       CONTINUE
214
215       CALL OTCRWD()
c Determine if additional stress that may affect tree mortality
222 c will occur this year. ISTRES is dependent variable that is used to
223 c invoke the stress called for by setting stress option ISOPT to 1 or
224 c 2. ISTRES = stress index (1 = no stress this year, 2 = stress will
225 c occur this year). if ISOPT =1, then stress occurs in years when a
226 c random number (using ISEED(3)) is less than the threshold value
227 c STRESS(ISITE). thus, STRESS(ISITERS) is the probability of additional
228 c random stress. random. If ISOPT=2, then the user has identified
229 c specific years when stress will occur by providing a list of those
230 c years. RANDS = pseudo-random number generator. ISEED(3) = seed for
231 c random number generator and stress.
232 ISTRES = 1
233 +---IF ((ISOPT .EQ. 1) THEN
234 | CALL RANDS(ISEED(3), X)
235 | IF (X .LT. STRESS(ISITE)) ISTRES = 2
236 +---ELSEIF ((ISOPT .EQ. 2) .AND. (ISTRyr .EQ. ISYEAR)) THEN
237 | ISTRES = 2
238 c If more stress years have been scheduled, get the next one.
239 | +---IF (NISTRYR .GT. 0) THEN
240 | | NISTRYR = NISTRYR - 1
241 | | READ (JSTRS, 10000) ISTRYR
242 | +---ENDIF
243 +---ENDIF
244
245 c (4)***************************************************************************
246 c Handle some management actions. If MANAGE=0, then no actions are
247 c scheduled; if MANAGE=1, then proportions to be cut have been
248 c specified by the user -- they will be applied later.
249 c See if any actions are scheduled for this year. ISYEAR=current year,
250 c MYEARS = year of next management action.
251 c
252 +---IF (MANAGE .GT. 0 .AND. MYEARS .EQ. ISYEAR) THEN
253 | IF (STABLE .OR. DEBUG) CALL PTSTRNL()
254 | +---IF (MANAGE .EQ. 1) THEN
255 | | +---DO IH = 1, NHOSTS
256 | | | READ (JTIM, 10010) CUTMIN(IH), CUTMAX(IH), PCUT(IH)
257 | | | CUTMIN(IH) = CUTMIN(IH)*2.54001
258 | | | CUTMAX(IH) = CUTMAX(IH)*2.54001
259 | | +---ENDDO
260 | +---ELSE
261 | +---DO IH = 1, NHOSTS
262 | | READ (JTIM, 10010) CUTMIN(IH), CUTMAX(IH), TARGET(IH)
263 | | CUTMIN(IH) = CUTMIN(IH)*2.54001
264 | | CUTMAX(IH) = CUTMAX(IH)*2.54001
265 | | TARGET(IH) = TARGET(IH)*2.471044
266 | +---ENDDO
267 | +---ENDIF
268 | IF (STABLE .OR. DEBUG) CALL PRTMG(
269 |
270 c The user has specified the target number of stems (MANAGE=2). Sum
271 c total stems (SUM) and the number of stems in the harvest range
272 c (TSUMDC). Set proportion to be cut by species (CUTPR) to zero.
273 c STEMS = no. of stems, DIAM = diam class index, EPSIMG(1) = min. no. of
276 c stems that must be present for a particular cell stem count to be
277 c accumulated. CUTMIN & CUTMAX are minimum & maximum diameters to be
278 c cut in this treatment (they have been set by the user).
279 |
280 |
281 | +--IF (MANAGE .EQ. 2) THEN
282 | | +--DO IH = 1, NHOSTS
283 | | | SUM = 0.0
284 | | | TSUMDC = 0.0
285 | | | +--CUTPR(IH) = 0.0
286 | | | +--DO ID = 1, NDIAM
287 | | | | +--IF (STEMS(IH, ID) .GE. EPSIMG(1)) THEN
288 | | | | | IF (DIAM(ID) .GE. CUTMIN(IH) .AND. DIAM(ID) .LT. 
289 | | | | | | CUTMAX(IH)) TSUMDC = TSUMDC + STEMS(IH, ID)
289 | | | | | +--ENDIF
290 | | | +--ENDIF
291 | | +--ENDDO
292 |
293 |
294 c Calc. total no. of stems to be harvested (TOBCUT) based on target
295 c no. of trees to remain (which has been specified by the user).
296 c Set the proportion of stems to be cut by species (CUTPR) if there
297 c are sufficient stems in the species for the specified diameter range.
298 |
299 | | TOBCUT(IH) = SUM - TARGET(IH)
300 | | | IF (TOBCUT(IH) .LT. 0.0) TOBCUT(IH) = 0.0
301 | | +--IF (TSUMDC .GT. EPSIMG(2)) THEN
302 | | | | +--IF (TOBCUT(IH) .GE. TSUMDC) THEN
303 | | | | | CUTPR(IH) = 1.0
304 | | | | | +--ELSE
305 | | | | | | CUTPR(IH) = TOBCUT(IH)/TSUMDC
306 | | | | | +--ENDIF
307 | | | +--ENDIF
308 | | +--ENDIF
309 | +--ENDIF
310 +--ENDIF
311 |
312 c (5)**************************************************************************************************
313 c If DEBUG, write a header line for annual stand data output
314 c ++IF (DEBUG) THEN
315 c | WRITE (JSOUT1, *) 'Debug output from TREE21:10020:'
316 c | WRITE (JSOUT1, 10020) (DIAM(ID), ID = 1, 20)
317 c +--ENDIF
318 |
319 RETURN
320 |
321 |
322 c End of subroutine TREE21 -- File name TREE21.FOR
***** Subroutine TREE22. file: TREE22.FOR *****

A portion of the:
Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
revised by K. Sheehan January 1988; revised starting in 1989
by Colbert and Racin.

J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

This section calculates diameter growth and mortality rates
for each tree species & diameter class, followed by recruitment of
new stems and management entries. First the temperature modifier of
growth is calculated for each species; then for each diameter class
and host, the defoliation modifier, the shading modifier, the
potential and actual growth are calculated. Then the mortality
factors are calculated and accumulated (past and current defoliation,
stress, slow growth and background rates). Growth and mortality
effects are summarized for tabular and ASCII file output. Growth is
simulated by moving the stem counts between diameter classes.
Management entries (tree removals) are simulated followed by further
summarizing of the stand for output. Finally, defoliation histories
(by tree species and crown strata) for the year is updated.

Called from main program DAMSR.
Calls subroutines RANDS, FRTMGT, and PTSTBL if conditions are met.

** Local variables, parameters, and inputs required
by Subroutine TREE22() **
The following designations for LOCATIONs apply:
(1) - 1 := local variable
(2) - n := new parameter; not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXN := CAPS or CAPS+digit indicate a common block name

NAME - LOCATION - DESCRIPTION
-----------------------------------------------
ALIGHT 1 - Available light, see equation (I).
ANNUD WTHR1 - The total number of degree-days above
a 42 degree F. threshold.
BA S2 - Basal area (by host & strata).
BASAL 1 - Basal area.
BDIE S1 - Background tree mortality rate, by host.
R1 S1 - Parameter for calc. tree height.
B2 S1 - Parameter for calc. tree height.
COLD S2 - Minimum annual degree-days tolerated, by host.
CROWD S2 - Crowding index (a tree growth modifier).
CUTMAX S4 - Maximum diameter to be cut, by host and year.
CUTM1 S4 - Minimum diameter to be cut, by host and year.
CUTN 1 - Number of trees to be cut by species.
CUTFR S4 - Proportion to be cut by species
DDIE 1 - Proportion of trees that will die following
defoliation (calc. by host and diam. class).
DEB Bug LOG1 - Logical variable, true to produce debug output.
56 c DEFIND S2 - Defoliation index (a tree growth modifier).
57 c DEPL S3 - Percent defoliation, by host and strata.
58 c DEGDT WTHR1 - Total degree-days for the current year.
59 c DFLC(i,j) S3 - For j=1,2; i=1,2: parameters for equation (13)
60 c (light) and equation (14) (heavy) for predicting
61 c define (eqn. (16)), the effect of current defolia-
62 c tion on diameter growth.
63 c DIAM S1 - Diameter at mid-point, by diameter class.
64 c DIAMCL 1 - DBH squared for each diameter class.
65 c DLKN S1 - Length of diameter class (cm).
66 c DMAX S1 - Maximum diameter at breast height (cm), by host.
67 c DMEAN S2 - Quadratic mean dbh by host and strata.
68 c EPSIGR S2 - Decision parameter for including stems(host,diam) in
69 c growth calculations, if >0 then small stems counts
70 c will not enter into these calculations.
71 c EPSIMG S4 - Min. no. of stems that must be present for a
72 c particular cell stem count to be accumulated
73 c EPSITR S2 - Decision parameter for including stems(h,d) in
74 c transfer between diameter classes.
75 c FDIE S1 - Proportion of trees that die because of defoliation,
76 c based on host, number of years of defoliation, and
77 c site.
78 c GDIE 1 - Proportion of trees that die following slow growth.
79 c GROW 1 - Actual annual diameter tree growth, by host and
80 c diameter class, in cm.
81 c GROWMX S2 - Potential diameter growth, by host and diam. class.
82 c GROWR S1 - Parameter for calc. potential annual diam. growth.
83 c HEIGHT S1 - Tree heights (cm), by host and diameter class.
84 c HMAX S1 - Maximum height (cm), by host.
85 c HOT S2 - Maximum annual degree-days tolerated, by host.
86 c HOVER S2 - Height or diameter (cm) that separates over- and
87 c understory trees.
88 c IBOUND S4 - Overstory/understory boundary type: 1=height (ft or
89 c cm), 2=diameter (in or cm).
90 c ID 1 - Diameter class number.
91 c IDHIST S3 - Defoliation history for the past two years: 0=none,
92 c 1=light (0.1-29.9%), 2=medium (30-64.9%), 3=heavy
93 c (65+%), by host and strata.
94 c IHEAVY 1 - Host species index.
95 c IHEAVY 1 - Temporary variable storing heavy defoliation for
96 c past two yrs.
97 c IN 1 - Index for reading in Shade and Stocking effect
98 c values.
99 c IS 1 - Strata number.
100 c ISEED GEN1 - Random number seeds (1= recruitment of new trees, 2= not used at this time, 3= additional tree mortality due to stress, 4= add. gypsy moth mortality due to winter temperatures, 5= for weather generator, 6= gypsy moth L1 dispersal).
101 c ISHADE S4 - Shade tolerance class by species (1=recruitment, 2= diameter growth).
102 c ISITE S4 - Index for site (1=moist, 2=intermediate, 3=dry).
103 c ISTRAT 1 - Set to 1 for overstory, 2 for understory.
104 c ISTRES S4 - Set to 2 if current year is a stress year.
105 c ISYEAR GEN1 - Starting year; example: 1987. Then incremented to
111 c contain calendar year of simulation.
112 c ITEST 1 - Temporary variable storing defoliation history
113 c for past two years.
114 c I WOPT  GEN1 - Weather option: 1=1 year of data, 2=>1 year of data,
115 c 3=generate data with Subr. WGEN, 4=use annual total
116 c degree-days.
117 c I YEAR  GEN1 - Current year in the simulation.
118 c JDB  GEN1 - Number of file that contains debug output.
119 c JSOUT1  GEN1 - Number of file: stand output.
120 c MANAGE  S4 - Stand management option: 0=no actions, 1=user
121 c specifies proportions to be cut, 2=user specifies
122 c target no. of stems.
123 c METRIC  LOG2 - Set to true if input/output units are to be metric.
124 c MYEARS  S4 - Years that management actions have been scheduled
125 c (for example: if MYEARS(1)=1990, then first harvest
126 c occurs in 1990).
127 c NDEF(ih,id) 1 - Number of years of heavy defoliation (>65%), by host
128 c and diameter class.
129 c NDIAM  S4 - Number of diameter classes to be simulated.
130 c NEWST 1 - Indicates first diameter class only.
131 c NHOSTS  GEN1 - Number of hosts to be simulated.
132 c NSLOW(ih,id) 1 - Number of years of slow growth (<.01cm/yr), by host
133 c and diameter class.
134 c OVERS  S3 - Total count of overstory stems, by species.
135 c PCUT  S4 - Proportion of trees to be cut, by host and year.
136 c PTSTBL  s - Random number returned by RANDS.
137 c RANDS  s - Maximum number of seedlings that can be recruited
138 c into the smallest diameter class, by host.
139 c RECRUT  S1 - Local Real variable in TREE22 holds shading
140 c effect on stocking of new recruits.
141 c RSHADE  1 - Relative stocking index for the stand.
142 c RSTOCK  S3 - Proportion of mortality due to stress, by host.
143 c SDIE  1 - Proportion of trees that will die due to stress in
144 c years of heavy defoliation.
145 c SGMORT  S2 - No. of years of slow growth (nslow) effect on tree
146 c mortality rate. exponential rate coefficient for
147 c calculating gdie, eqn. (18).
148 c SHADE  1 - Tree growth modifier for shading for a given tree.
149 c SHADMN  S1 - Minimum value for shade in equation 16.
150 c SHX  S1 - Parameter for effect of light on diam. growth by
151 c shade tolerance index.
152 c SHY  S1 - Parameter for effect of light on diam. growth by
153 c shade tolerance index.
154 c SLIP  1 - Function that interpolates between data points.
155 c SLOWD  S1 - Minimum annual growth needed to avoid additional
156 c mortality
157 c SMFDIE  S2 - Mean tree mortality due to defoliation, by host
158 c and strata.
159 c SMGDIE  S2 - Mean tree mortality due to slow growth.
160 c SMKROW  S2 - Mean actual diameter growth.
161 c SMGRO  S2 - Mean potential diameter growth.
162 c SMHAD  S2 - Mean shading growth modifier.
163 c SMTHDIE  S2 - Mean total tree mortality.
166c STABLE LOG2 - Set to true if stand submodel output is desired.
167c STEM S2 - Number of stems (by host & strata)
168c STEMS S1 - Number of stems, by host and diameter class.
169c STOKX S1 - Relative stocking parameter for effect of relative
170c c stocking on recruitment.
171c STOKY S1 - Recruitment parameter for effect of relative
172c c stocking on recruitment.
173c STRFAC S1 - Proportion of trees that die because of stress.
174c SUMLFA S2 - Sum of leaf surface area for all trees taller than a
175c c given height, by host and diameter class.
176c TDIE 1 - Total proportion of trees that die.
177c TEMP S2 - Tree growth modifier for temperature, by host.
178c TEMPW S1 - Minimum value for TEMP in equation 11(b).
179c TEMPX(4) 1 - Temporary storage variable for SHX.
180c TEMFY(4) 1 - Temporary storage variable for SHY.
181c TPAC WTHR1 - Multiplier used to change all temperature values by
182c a certain proportion (set to 1.0 by default).
183c TKL S2 - Parameter for calculating available light.
184c TLIGHT S2 - Parameter for calculating available light.
185c TNAME CHA1 - Tree code, by host.
186c TOBCUT S4 - Total no. of stems to be harvested.
187c TOBRA SUM - Total basal area (over+understory), by host.
188c TOBDBH SUM - Quadratic mean diameter for all trees,
189c c by host species.
190c TOSTM SUM - Total number of trees (over+understory), by host.
191c TOTVOL SUM - Total volume (over+understory), by host.
192c TREEN(id) 1 - Temporary variable storing STEMS times GROW, divided
193c c by DLEN.
194c TSTEM 1 - Temporary variable storing STEMS.
195c UNDERS(ih) S3 - Total count of understory stems, by species.
196c VOL(ih,is) S2 - Total live tree volume (by host & strata)
197c c VOLUME 1 - Volume of right-circular cone, \( \pi r^2 h/3 \).
198c c YIELD 1 - Yield accumulator variable, used to calculate and
199c c load the YLD variables.
200c YLD(ih,is) S2 - Yield (volume of harvested trees, by host & strata)
201c 202
203SUBROUTINE TREE22
204  10000 FORMAT(' TREE22:4765: IYEAR = ',I5, ', ANNDD(IYEAR) = ', F10.2,
205  * ', TPAC = ', F10.5, ', DEGDT = ', F10.5, ', Species Co', 'de = ',
206 * ', A3, ', TEMP(IH) = ', F10.5)
207  10010 FORMAT (3X, A3, 3X, 20F6.2)
208  10020 FORMAT ('POTGROWTH', 20F6.4)
209  10030 FORMAT ('ACTGROWTH', 20F6.4)
210  10040 FORMAT (2X, A5, 2X, 20F6.4)
211  10050 FORMAT ('NEWST = ', F10.4, ', STEMS(IH,1) = ', F10.4,
212  * ', RANDRC = ', F10.6, ', RSHADE = ', F10.4, ', RECRUT(IH) = ',
213  * F10.4)
214
215c ***** Common Blocks Included:
216
217INCLUDE 'CHA1.CMB'
218INCLUDE 'GEN1.CMB'
219INCLUDE 'LOG1.CMB'
220INCLUDE 'LOG2.CMB'
INCLUDE 'S1.CMB'
INCLUDE 'S2.CMB'
INCLUDE 'S3.CMB'
INCLUDE 'S4.CMB'
INCLUDE 'SUM.CMB'
INCLUDE 'WTHR1.CMB'

c ***** Local variable definitions and initialization:

REAL*8 NEWST

DIMENSION GROW(20), NSLOW(12, 20), NDEF(12, 20)
DIMENSION TEMPX(4), TEMPY(4), TREEN(20)

DATA NSLOW, NDEF/480*0/

 Do the following growth and mortality calculations for each host

 ---DO IH = 1, NHOSTS

 c Initialize summary variables to zero.

 OVERS(IH) = 0.0
 UNDERS(IH) = 0.0
 TOTSTM(IH) = 0.0
 TOTRA(IH) = 0.0
 TOTVOL(IH) = 0.0

 ---DO ISTRAT = 1, 2

 RSTRES(IH, ISTRAT) = 0.0
 SMGROW(IH, ISTRAT) = 0.0
 SMPROG(IH, ISTRAT) = 0.0
 SMSHAD(IH, ISTRAT) = 0.0
 SMTDIE(IH, ISTRAT) = 0.0
 SMFDE(IH, ISTRAT) = 0.0
 SMDIE(IH, ISTRAT) = 0.0
 DMEAN(IH, ISTRAT) = 0.0
 STEM(IH, ISTRAT) = 0.0
 BA(IH, ISTRAT) = 0.0
 VOL(IH, ISTRAT) = 0.0
 YLD(IH, ISTRAT) = 0.0

 ---ENDDO

 c Compute the growth modifier for temperature (=TEMP(ih)).

 DEGDT = annual degree-days for trees. If IWOPT=4, annual deg.days
 have been provided by the user (=ANNDDE) & may be modified by a
 temperature multiplier (TFAC, set to 1.0 by default). Otherwise,
 annual deg-days have been calc. in subr. WATHER & stored in DEGDT.
 HOT & COLD are the max. and min. deg-days found in a species
 geographic range. the relation is taken from JABOWA. The
 c minimum value has been arbitrarily set to 0.05, this minimum value is
 now user accessible through parameter TEMPMN.

 IF (IWOPT .EQ. 4) DEGDT = ANNDDE(IYEAR)*TFAC
 TEMP(IH) = 4*(DEGDT - COLD(IH))*HOT(IH) - DEGDT)/(HOT(IH) -
 COLD(IH))**2
IF (TEMP(IH) .LT. TEMPMN) TEMPMN = TEMP(IH)
IF (DEBUG) WRITE (JDB, 10000) IYEAR, AANNOD(IYEAR), TFAC,
* ! DEGDY, TNAME(IH), TEMP(IH)

Do the following preliminary calculations for each diameter class.
No changes have been made to the stems per acre STEMS(ih,id) yet!

************
IF (DEBUG) WRITE (JSOUT1, 10010) TNAME(IH), (STEMS(IH,ID), ID
* = 1, NDIAM)
************

DO ID = 1, NDIAM
Determine which strata this diameter class belongs to
ISTRAT = 1

IF (IBOUND .EQ. 1) THEN
IF (HEIGHT(IH, ID) .LT. HOVER) ISTRAT = 2
ELSE
IF (DIAM(ID) .LT. HOVER) ISTRAT = 2
ENDIF

Calculate growth modifier due to defoliation (=DEFIND)
Based on defoliation history for previous 2 years (stored
in IDHIST (0=none, 1=light, 2=medium, 3=heavy) and current
defoliation (DEFL).
(equ. from Sheehan (unpubl.) interpretation of literature)

TEST = IDHIST(IH, ISTRAT, 1) + IDHIST(IH, ISTRAT, 2)
HEAVY = 0
IF (IDHIST(IH, ISTRAT, 1) .EQ. 3 .OR. IDHIST(IH, ISTRAT, 2)
* .EQ. 3) HEAVY = 1

IF (TEST .EQ. 0 .AND. DEFL(IH, ISTRAT) .LE. 0.0) THEN
DEFINE(IH, ISTRAT) = 1.0
ELSEIF (TEST .LE. 3 .AND. HEAVY .EQ. 0) THEN
DEFINE(IH, ISTRAT) = DFCL(1, 1) + DFCL(1, 2)*DEFL(IH,
* ISTRA)
ELSE
DEFINE(IH, ISTRAT) = 1.0/(DFCL(2, 1) + DFCL(2, 2)*DEFL(IH,
* ISTRA))
ENDIF

Calc. growth loss due to shading (=SHADE)
Available light (ALIGHT) is calc. based on foliage area above (SUMLFA)
Using exponential approach of JABOWA. TLIGHT is set to 1.0 by default
and TKL was arbitrarily set by Sheehan (following the technique
used in JABOWA). ISHADE(ih,2) stores the shade tolerance index for
calc. diam. growth. SHX and SHY store the coordinates of
calc. 4-pt. step functions that describe the relation between avail.
light and diam. growth for a given shade tolerance index. These
coordinates are temporarily stored in TEMPX and TEMPY when using the
SLIP function to interpolate between points. If SHADE is below the
minimum value (SHADMN = 0.05 by default) then it reset to the min.
ALIGHT = TLIGHT*EXP(-TKL*SUMLFA(IH, ID))

DO IN = 1, 4
   TEMPX(IN) = SHX(ISHADE(IH, 2), IN)
   TEMPY(IN) = SHY(ISHADE(IH, 2), IN)
ENDDO

SHADE = SLIP(ALIGHT, TEMPX, TEMPY, 4)

IF (SHADE .LT. SHADMN) SHADE = SHADMN

Calc. potential growth (= GROWMX) using function from JABOWA.
also see equations (15) and (16) in the documentation.
DMAX=maximum diameter, HMAX=maximum height, B1 and B2 = parameters
c used to calculate tree height. GROWR = optimum growth parameter from
JABOWA or FORRT. Next, calc. actual growth (=GROW) by applying the
4 growth modifiers calc. earlier to the amount of potential growth.
GROWMX and grow units = cm per year. This is calculated only for
cells where the stem count is above min. count EPSIGN (default 0.0).

GROW(ID) = 0.0

IF (STEMS(IH, ID) .GE. EPSIGN) THEN
   GROWMX(IH, ID) = GROWR(IH)*DIAM(ID)*{(1. - DIAM(ID)}
   *HEIGHT(IH, ID)/(DMAX(IH)*HMAX(IH)))/(274. + DIAM(ID)*
   (3.*B1(IH) - 4.*B2(IH)*DIAM(ID))
   GROW(ID) = GROWMX(IH, ID)*DEFIND(IH, ISTRAT)*SHADE*TEMP
   IF (GROW(ID) .LT. 0.) GROW(ID) = 0.0
ENDIF

Calculate tree mortality
First, calc. mortality following defoliation.
NDEF = number of years with continuous heavy defoliation.
DDTR = proportion of trees that will die following defoliation.
DEFL = defoliation (host, strata)
FDIE = mortality rate for species ih on site type *ISITE* after
c NDEF years of continuous heavy defoliation.
SDIE = additional mortality due to stress (can only occur in
c years with heavy defoliation)
ISTRES = 1 if no stress occurs this year, = 2 if no stress occurs
c (was set earlier in this subroutine)
STRFC = mortality rate due to stress (value 1 = rate with no stress,
c = value 2 = rate with stress)

DDIE = 0.0
SDIE = 0.0
NDEF(IH, ID) = NDEF(IH, ID) + 1
IF (DEFL(IH, ISTRAT) .LE. 65.0) NDEF(IH, ID) = 0
IF (NDEF(IH, ID) .GT. 3) NDEF(IH, ID) = 3
IF (NDEF(IH, ID) .GT. 0) THEN
   DDIE = FDIE(IH, NDEF(IH, ID), ISITE)
   SDIE = STRFC(ISTRES)
ENDIF

Next, calc. additional mortality following years of slow growth
(function came from JABOWA)
NSLOW = number of years of slow growth (less than SLOWD cm/yr)
385 c SLOWD(ih) = minimum growth (cm/yr) required to avoid add. mortality
386 c GDIE = proportion of trees that die following slow growth.
387 | |
388 | | NSLOW(IH, ID) = NSLOW(IH, ID) + 1
389 | | IF (GROW(ID) .GT. SLOWD(IH)) NSLOW(IH, ID) = 0
390 | | IF (NSLOW(IH, ID) .GT. 10) NSLOW(IH, ID) = 10
391 | | GDIE = 1. - EXP(SGMORT*FLOAT(NSLOW(IH, ID)))
392 | |
393 | |
394 c Finally, calc. total mortality rate
395 c BDie = base or background mortality rate
396 c TDIE = total proportion of trees that die.
397 |
398 | | TDIE = BDie(IH) + GDIE + DDIE + SDIE
399 | | IF (TDIE .GT. 1.) TDIE = 1.
400 | | STEMS(IH, ID) = STEMS(IH, ID)*((1 - TDIE)
401 | |
402 c Causes of growth loss and mortality are summed (for output)
403 c by species for overstory and understory trees. Weighted means
404 c will be calc. for pot. growth (SMFGRO), actual growth (SMGROW),
405 c shading (SMDHAD), total mortality (SMTDIE), slow growth mortality
406 c (SMGDIE), defoliation mortality (SMDFDIE), & stress mort. (RSTRES)
407 |
408 | | | | | ---IF (ISTRAT .EQ. 1) THEN
409 | | | | | +---ELSE
410 | | | | | | UNDESR(IH) = UNDESR(IH) + STEMS(IH, ID)
411 | | | | | +---ENDIF
412 | | | | +---ENDIF
413 | | | | SMFGRO(IH, ISTRAT) = SMFGRO(IH, ISTRAT) + (GROWX(IH, ID)
414 | | | | + *STEMS(IH, ID))
415 | | | | SMGROW(IH, ISTRAT) = SMGROW(IH, ISTRAT) + (GROW(ID)*STEMS
416 | | | | (IH, ID))
417 | | | | SMDHAD(IH, ISTRAT) = SMDHAD(IH, ISTRAT) + (SHADE*STEMS(IH,
418 | | | | ID))
419 | | | | SMTDIE(IH, ISTRAT) = SMTDIE(IH, ISTRAT) + (TDIE*STEMS(IH,
420 | | | | ID))
421 | | | | SMGDIE(IH, ISTRAT) = SMGDIE(IH, ISTRAT) + (GDIE*STEMS(IH,
422 | | | | ID))
423 | | | | SMDFDIE(IH, ISTRAT) = SMDFDIE(IH, ISTRAT) + (DDIE*STEMS(IH,
424 | | | | ID))
425 | | | | RSTRES(IH, ISTRAT) = RSTRES(IH, ISTRAT) + (SDIE*STEMS(IH,
426 | | | | ID))
427 | | | |
428 | | | | +---ENDDO
429 |
430 |
431 c ***************************************************************
432 | | | ---IF (DEBUG) THEN
433 | | | | WRITE (JSOUT1, 10010) TNAME(IH), STEMS(IH, ID), ID = 1,
434 | | | | NDIM
435 | | | | WRITE (JSOUT1, 10020) GROWX(IH, ID), ID = 1, NDIM
436 | | | +---ENDIF
437 |
438 c ***************************************************************
439 |
440 c If appropriate, move trees from one diameter class to another,
c starting with the largest trees. The proportion that move up =
442 c ratio of diameter growth for this diam. class (GROW) to the
443 c width of this diam. class (DLEN). Only move trees if the
444 c num. of new trees to be added is greater than the tree transfer epsilon
445 c value (EPSITR) set by user (default=0.0). Don't move trees into diam.
446 c classes that are larger than the maximum diameter (DMAX) for sp. ih.
447 |
448 |
449 | ++--DO ID = NDIAM - 1, 1, -1
450 | ++--IF (((DIAM(ID) + DLEN(ID)/2.0) .LT. DMAX(IH)) THEN
451 | | | TREEN(ID) = STEMS(IH, ID)*GROW(ID)/DLEN(ID)
452 | |
453 | |
454 |
455 | |
456 | |
457 | ++--ENDIF
458 |
459 |
460 |
461 |
462 | ++--IF (DEBUG) THEN
463 | | | WRITE (JOUT1, 10040) 'TREEN', (TREEN(ID), ID = 1, NDIAM)
464 | | | WRITE (JOUT1, 10010) TNAMK(IH), (STAMS(IH, ID), ID = 1, NDIAM)
465 | |
466 | ++--ENDIF
467 |
468 |
469 |
470 |
471 |
472 c Apply cutting if scheduled. If manage=0, no cutting is scheduled.
473 c If (MYEARS is less than ISYEAR), then cutting is scheduled, but not
474 c for this year.
475 c CUTMIN(ih) = minimum diameter class to be cut for species ih,
476 c CUTMAX(ih) = maximum diameter class to be cut.
477 |
478 c if MANAGE=1, user has specified proportions to be cut.
479 c the proportions are applied to all trees with the diameter
480 c limits specified by CUTMIN and CUTMAX.
481 c If MANAGE=2, the user has chosen target residual stem counts.
482 c TARGET residuals are in relation to the total stem counts for
483 c each species and not just trees within the cutting diameter limits.
484 c Trees will only be cut if their diameter class falls
485 c between CUTMIN and CUTMAX. When a diameter class of a given
486 c species is within the "cut range", the proportion of trees in
487 c that diameter class that will be cut is set by FCUT(ih).
488 |
489 | |
490 | |
491 | |
492 | |
493 | |
494 | |
495 | |
496 | |
497 | |
498 | |
499 | |
500 | | YIELD = 0.0
501 | | ++--IF (MANAGE .GT. 0 .AND. MYEARS .EQ. ISYEAR) THEN
502 | |
503 | |
504 | |
505 | |
506 | |
507 | |
508 | |
509 | | IF (DIAM(ID) .GE. CUTMIN(IH) .AND. DIAM(ID) .LE. 
510 | | ++--CUTMAX(IH)) THEN
511 | |
512 | |
513 | |
514 | |
515 | |
516 | |
517 | |
518 | | YIELD = (STAMS(IH, ID)*DIAM(ID)*DIAM(ID)* 
519 | | (3.14159/12.)*HEIGHT(IH, ID)*FCUT(IH)/1E6)
STEMS(IH, ID) = STEMS(IH, ID)*(1. - PCUT(IH))
+-ENDIF

User has selected a target number of stems (MANAGE=2). CUTPR
stores the proportion of trees to be cut by species (calc.
earlier in this subroutine). Specified target may leave few trees to
be cut (TOBCUT(IH)) and user may specify minimum sufficient for
c removal as EPSIMG(3) (default 0.0).

ELSEIF (TOBCUT(IH) .GT. EPSIMG(3)) THEN
   IF (DIAM(ID) .GE. CUTMIN(IH) .AND. DIAM(ID) .LE. CUTMAX(IH)) THEN
      YIELD = ((CUTNUM*DIAM(ID)*DIAM(ID)*3.14159
                /12.0*HEIGHT(IH, ID)/1E6)
   ENDIF
   STEMS(IH, ID) = STEMS(IH, ID) - CUTNUM
+-ENDIF

IF ((STABLE .OR. DEBUG).AND.
   (1D.EQ. ND1AM).AND.(1H .EQ. NHOSTS))
   CALL PTSTBL()
+-ENDIF

Add recruitment (# stems that grow into the smallest diam. class)
for first diameter class only (=NEWST)
ISHADE(ih,1) = shading tolerance class (1=most tol., 5=least tol.)
RSTOCK = relative stocking for stand (calc. in tree1)
ISEED(1) = pseudo-random number seed for recruitment.
RECRUT(ih) = maximum number of trees that can be recruited in one
year by species ih (arbitrarily set by k.sheehan)
STORX & STORY store parameters that adjust max. # of trees recruited
based on ISHADE(ih) and RSTOCK.

IF (ID .EQ. 1) THEN
   DO IN = 1, 4
   TEMPX(IN) = STOKX(ISHADE(IH, 1), IN)
   TEMPY(IN) = STOKY(ISHADE(IH, 1), IN)
   RSHADE = SLIP(RSTOCK, TEMPX, TEMPY, 4)
   CALL RANDS(IH, RANDRC)
   NEWST = RECRUT(IH)*RANDRC*RSHADE
   STEMS(IH, 1) = STEMS(IH, 1) + NEWST
   ENDDO

******************************************************************************

IF (DEBUG) THEN
   WRITE (JSOUT1, 10050) NEWST, STEMS(IH, 1), RANDRC,
   RSHADE, RECRUT(IH)
   CALL PTSTBL()
   ENDIF

Calculate basal area in m2/ha and volume in m3/ha for the
current species and diameter class.

    BASAL = (DIAM(ID)**2*(3.14159/4.))*STEMS(IH, ID)/1E4
Volume = vol. of right-circular cone, \( \pi r^2 h/3 \).

\[ \text{VOLUME} = \text{HEIGHT(IIH, ID)} \times \text{BASAL}/300. \]

\[ \text{DIACL} = \text{DIAM(IIH)} \times \text{STEMS(IIH, ID)} \]

\[ \text{TSTEM} = \text{STEMS(IIH, ID)} \]

Sum variables for this diameter class according to strata.

\[ \text{DBH} = \text{quadratic mean dbh} \]

\[ \text{STEM} = \text{number of stems (by host & strata)} \]

\[ \text{BA} = \text{basal area (by host & strata)} \]

\[ \text{VOL} = \text{total live tree volume (by host & strata)} \]

\[ \text{YLD} = \text{yield (volume of harvested trees, by host & strata)} \]

\[ \text{ISTRAT} = 1 \]

\[ \text{IF (IBOUND .EQ. 1)} \]

\[ \text{IF (HEIGHT(IIH, ID) .LT. HOVER) ISTRAT = 2} \]

\[ \text{ELSE} \]

\[ \text{IF (DIAM(IIH) .LT. HOVER) ISTRAT = 2} \]

\[ \text{ENDIF} \]

\[ \text{BA(IIH, ISTRAT)} = \text{BA(IIH, ISTRAT)} + \text{BASAL} \]

\[ \text{STEM(IIH, ISTRAT)} = \text{STEM(IIH, ISTRAT)} + \text{TSTEM} \]

\[ \text{VOL(IIH, ISTRAT)} = \text{VOL(IIH, ISTRAT)} + \text{VOLUME} \]

\[ \text{YLD(IIH, ISTRAT)} = \text{YLD(IIH, ISTRAT)} + \text{YIELD} \]

\[ \text{DMEAN(IIH, ISTRAT)} = \text{DMEAN(IIH, ISTRAT)} + \text{DIAMCL} \]

Total variables for graphics output

\[ \text{TOTSTM(IIH)} = \text{TOTSTM(IIH)} + \text{TSTEM} \]

\[ \text{TOTBA(IIH)} = \text{TOTBA(IIH)} + \text{BASAL} \]

\[ \text{TOTVOL(IIH)} = \text{TOTVOL(IIH)} + \text{VOLUME} \]

Calculate the quadratic mean diameter for each host.

\[ \text{TOTDBH(IIH)} = \sqrt{((\text{DMEAN(IIH, 1)} + \text{DMEAN(IIH, 2)})/(\text{STEM(IIH, 1)})^2)} \]

Convert the summed growth and mortality causes to averages by dividing the sums by the number of overstory stems (OVERS) or understory stems (UNDERS).

\[ \text{SMGRO(IIH, 1)} = \text{SMGRO(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{SMGRO(IIH, 1)} = \text{SMGRO(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{SMTSHAD(IIH, 1)} = \text{SMTSHAD(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{SMTDIE(IIH, 1)} = \text{SMTDIE(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{SMTDIE(IIH, 1)} = \text{SMTDIE(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{DMEAN(IIH, 1)} = \sqrt{((\text{DMEAN(IIH, 1)} \times \text{OVERS(IIH)})} \]

\[ \text{SMFIE(IIH, 1)} = \text{SMFIE(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{RSTRES(IIH, 1)} = \text{RSTRES(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{SMFIE(IIH, 1)} = \text{SMFIE(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{DMEAN(IIH, 1)} = \sqrt{((\text{DMEAN(IIH, 1)} \times \text{OVERS(IIH)})} \]

\[ \text{SMFIE(IIH, 1)} = \text{SMFIE(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{RSTRES(IIH, 1)} = \text{RSTRES(IIH, 1)} \times \text{OVERS(IIH)} \]

\[ \text{DMEAN(IIH, 1)} = \sqrt{((\text{DMEAN(IIH, 1)} \times \text{OVERS(IIH)})} \]

\[ \text{OVERS(IIH)} \]

\[ \text{UNDERS(IIH)} \]

\[ \text{OVERS(IIH)} \]

\[ \text{UNDERS(IIH)} \]
08-10-94 21:41:34 TREE22.FOR  Pg 12
Tue 08-16-94 16:24:51 TREE22  of 12
606  | | SNGROW(IH, 2) = SNGROW(IH, 2)/UNDERS(IH)
607  | | SM5HAD(IH, 2) = SM5HAD(IH, 2)/UNDERS(IH)
608  | | SMDIE(IH, 2) = SMDIE(IH, 2)/UNDERS(IH)
609  | | SM5DIE(IH, 2) = SM5DIE(IH, 2)/UNDERS(IH)
610  | | R5TRES(IH, 2) = R5TRES(IH, 2)/UNDERS(IH)
611  | | DMEAN(IH, 2) = SQRT(DMEAN(IH, 2)/UNDERS(IH))
612  | | ----ENDIF
613  | | ----IF (.NOT. METRIC) THEN
614  | | | SMPGRO(IH, 1) = SMPGRO(IH, 1)/2.54
615  | | SMPGRO(IH, 2) = SMPGRO(IH, 2)/2.54
616  | | SM5GROW(IH, 1) = SM5GROW(IH, 1)/2.54
617  | | SM5GROW(IH, 2) = SM5GROW(IH, 2)/2.54
618  | | ----ENDIF
619  | | ----ENDDO
620  |
621  | c Reset defoliation history
622  | |
623  | | DO IS = 1, 2
624  | | | IDHIST(IH, IS, 2) = IDHIST(IH, IS, 1)
625  | | | ----IF (DEFL(IH, IS) .LE. 0.0) THEN
626  | | | | IDHIST(IH, IS, 1) = 0
627  | | | | ----ELSEIF (DEFL(IH, IS) .LE. 30.0) THEN
628  | | | | | IDHIST(IH, IS, 1) = 1
629  | | | | | ----ELSEIF (DEFL(IH, IS) .LE. 65.0) THEN
630  | | | | | | IDHIST(IH, IS, 1) = 2
631  | | | | | | ----ELSE
632  | | | | | | IDHIST(IH, IS, 1) = 3
633  | | | | | | ----ENDIF
634  | | | | | | ----ENDDO
635  | | | | ----ENDDO
636  |
637  | c Change from metric to English units if METRIC = False.
638  | |
639  | | 1 sq ft/ac = 1 / 4.355983 sq m/ha
640  | | 1 cu ft/ac = 1 / 14.29123 cu m/ha
641  | | 1 inch = 2.540005 cm
642  |
643  | | ----IF (.NOT. METRIC) THEN
644  | | | ----DO IH = 1, NHOSTS
645  | | | | ----DO IS = 1, 2
646  | | | | | BA(IH, IS) = BA(IH, IS)*4.355983
647  | | | | | STEM(IH, IS) = STEM(IH, IS)/2.471044
648  | | | | | VOL(IH, IS) = VOL(IH, IS)*14.29123
649  | | | | | YLD(IH, IS) = YLD(IH, IS)*14.29123
650  | | | | | DMEAN(IH, IS) = DMEAN(IH, IS)/2.540005
651  | | | | | ----ENDDO
652  | | | | TOTSTM(IH) = TOTSTM(IH)/2.471044
653  | | | | TOTBA(IH) = TOTBA(IH)*4.355983
654  | | | | TOTVOL(IH) = TOTVOL(IH)*14.29123
655  | | | | TOTDBH(IH) = TOTDBH(IH)/2.540005
656  | | | | ----ENDDO
657  | | | | ----ENDIF
658  | | | RETURN
659  |
660  | c *** End of Subroutine TREE22 -- File name TREE22.FOR ***
***** Subroutine WASCII, file: WRITASCI.FOR *****

A portion of the:

Stand-Damage Model - a portion of the Gypsy Moth Life System Model
(the stand submodel) converted to a stand-alone model. Last
revised by K. Sheehan January 1988; revised starting in 1989
by Colbert and Racine.

J. Colbert, Northeastern Forest Experiment Station
180 Canfield St., Morgantown, WV 26505 (304)-285-1600

This section writes to the ASCII data files.
Called from main program DAMSR.
No calls to subroutines are made by this routine.

** local variables, parameters, and inputs required
by subroutine WASCII **
the following designations for LOCATIONS apply:
(1) - I := local variable
(2) - n := new parameter: not yet assigned to a common block
(3) - cp := call parameter of this subroutine
(4) - s := subroutine called from within this code
(5) - XXN := caps or caps+digit indicate a common block name

------------------------
NAME - LOCATION - DESCRIPTION
------------------------
BA     S2 - Basal area, by host and strata
DMEAN S2 - Mean diameter, by host and strata
ICAT  S4 - Tree graphics category: 1=overstory, 2=understory
IGYEAR S4 - Interval (years) for printing stand graph files
IH     1 - Host index
ISYEAR GEN1 - Starting year
JSOUT2 GEN1 - File number: number of stems (for graph)
JSOUT3 GEN1 - File number: basal area (for graph)
JSOUT4 GEN1 - File number: volume (for graph)
JSOUT5 GEN1 - File number: mean DBH (for graph)
KGYEAR S4 - Counter for number of years since last
writing of ASCII data for file(s).
NHOSTS U6N1 - Number of hosts to be simulated
STEM   S2 - Number of stems, by host and strata
TGBA   LOG2 - True to get basal area graph file
TDGDBH LOG2 - True to get mean DBH graph file
TDSTEM LOG2 - True to get stem number graph file
TGVOL  LOG2 - True to get volume graph file
TOTBA  SUM - Total basal area (over+understory), by host
TOTDBH SUM - Mean diameter for all trees, by host species.
TOTSTM SUM - Total number of trees (over+understory), by host
TOTVOL SUM - Total volume (over+understory), by host
VOL    S2 - Stand volume by host and strata

-------------------------------
SUBROUTINE WASCII
10000 FORMAT (I5, 12F9.2)
10010 FORMAT (I5, 12F11.2)
10020 FORMAT (I5, 12F9.3)
INCLUDE 'CHAR1.CMB'
INCLUDE 'GEN1.CMB'
INCLUDE 'LOG2.CMB'
INCLUDE 'S2.CMB'
INCLUDE 'S4.CMB'
INCLUDE 'SUM.CMB'

C Write data to ASCII files.

---IF (KGYEAR .EQ. IGYEAR) THEN
  +---IF (ICAT .EQ. 1) THEN
    * IF (TGSTEM) WRITE (JSOUT2, 10000) ISYEAR, (STEM(IH, 1), IH
    * = 1, NHOSTS)
    * IF (TGBA) WRITE (JSOUT3, 10000) ISYEAR, (BA(IH, 1), IH = 1,
      NHOSTS)
    * IF (TGVOL) WRITE (JSOUT4, 10010) ISYEAR, (VOL(IH, 1), IH =
      1, NHOSTS)
    * IF (TCDBH) WRITE (JSOUT5, 10020) ISYEAR, (DMEAN(IH, 1), IH
      = 1, NHOSTS)
    +---ELSEIF (ICAT .EQ. 2) THEN
      * IF (TGSTEM) WRITE (JSOUT2, 10000) ISYEAR, (STEM(IH, 2), IH
      = 1, NHOSTS)
      * IF (TGBA) WRITE (JSOUT3, 10000) ISYEAR, (BA(IH, 2), IH = 1,
        NHOSTS)
      * IF (TGVOL) WRITE (JSOUT4, 10010) ISYEAR, (VOL(IH, 2), IH =
        1, NHOSTS)
      * IF (TCDBH) WRITE (JSOUT5, 10020) ISYEAR, (DMEAN(IH, 2), IH
        = 1, NHOSTS)
    +---ELSE
      * IF (TGSTEM) WRITE (JSOUT2, 10000) ISYEAR, (TOTSTEM(IH), IH =
        1, NHOSTS)
      * IF (TGBA) WRITE (JSOUT3, 10000) ISYEAR, (TOTBA(IH), IH = 1,
        NHOSTS)
      * IF (TGVOL) WRITE (JSOUT4, 10010) ISYEAR, (TOTVOL(IH), IH =
        1, NHOSTS)
      * IF (TCDBH) WRITE (JSOUT5, 10020) ISYEAR, (TOTDBH(IH), IH =
        1, NHOSTS)
  +---ENDIF
  KGYEAR = 0
---ENDIF
RETURN
END

C End of subroutine WASCII -- File name WRITASCIFOR
Appendix D  Common Blocks for Stand-Damage Model

Each common block is contained in a separate file with the "*.cmb" extension. Using these blocks (file contents) where needed is accomplished using INCLUDE statements. The contents of each file follows.

-- File CHAR1.CMB taken from DAMAGE.FOR 11/21/89.

    COMMON /CHAR1/STRATA(*5), TNAME(*2)
    COMMON /UNITS(*7), UNITS2(*2), UNITS3(*2), UNITS4(*2), RNSPC1(*12)
    COMMON /RNSPC2, RNSPC3, RNSPC4, RNSPC5

-- File GEN1.CMB taken from DAMAGE.FOR 11/21/89.

    COMMON /GEN1/IVAR, NHOSTS, NWEAR, NYEAR, IYEAR, JGEN, JTN, JDB,
         ISEED(10), IWTN, JDRP, JSOFT1, JSOFT2, JSOFT3, JSOFT4,
         JSOUT5, IFORM, IWOPT, IYEAR, NUMLIN, JSTRS, NLLINES

-- File LOG1.CMB taken from INITW.FOR 11/21/89.

    LOGICAL IRAIN, DEBG
    COMMON /LOG1/IRAIN, DEBG

-- File LOG2.CMB taken from DAMAGE.FOR 11/21/89.

    LOGICAL METRIC, LDEFOL, TSTEM, TGBA, TGVOL, TGBH, STABLE, TEMPC
    COMMON /LOG2/METRIC, LDEFOL, TSTEM, TGBA, TGVOL, TGBH, STABLE, TEMPC

-- File S1.CMB taken from TPRINT.FOR 11/21/89.

    COMMON /S1/STEMS(12,20), HEIGHT(12,20), DIAM(20), DLEN(20),
         SURFA(12), B1(12), B2(12), F1(12), F2(12), GROW(12), DMAX(12),
         DMX(12), SHADM, BDIE(12), FDIE(12,3), STRFAC(2), STRESS(3),
         CR1(12), CR2(12), CR3(12), CR4(12), ISTOKG(12), REST(12,2),
         SHX(6,4), SHY(6,4), ACemax(13), SLOWD(12), RECRUT(12),
         STOKX(6,4), STOKY(6,4), TEMPN

-- File S2.CMB taken from DAMAGE.FOR 11/21/89.

    COMMON /S2/DMRAIN(12,2), SMDHUR(12,2), SMDTLE(12,2), SSTDRES(12,2),
         PLOTSZ, DEFIND(12,2), TEMP(12), BA(12,2), STEM(12,2), VOL(12,2),
         YLD(12,2), SGROW(12,2), SMTDIE(12,2), SMGDIE(12,2), TLIGHT,
         TRL, CROWD, GROWMX(12,20), SMPGRO(12,2), HOVER, FRTMIN, COUL(12),
         HOT(12), RSMULT, EPS1G, EPS1T, CROWDM, SGMORT, STOCKS(3,3),
         SUMLF4(12,20)

-- File S3.CMB taken from DAMAGE.FOR 11/21/89.

    COMMON /S3/IDFOLY, DEFL(12,3), DFLC(2,2), OVERS(12), UNDERS(12),
         RSTOCK, ACTFOL(12,3), POL(12,3), OVERBA(12), UNDBA(12),
         RSITES(12,4), DFOLE, IDHIST, DM5STM(12,2), PLOTR, STNDR

-- File S4.CMB taken from DAMAGE.FOR 11/21/89.

    COMMON /S4/ISHADE(12,2), ISOPT, ISTR(15), NDIAM, ISITE, IGYEAR, KGYEAR,
         ICAT, IBOUND, IVIEW(20), NSTRYR, ISTRYR, ISTRES, MANAGE, MOTAL,
         MÅNEN, CUTMIN(12), CUTMAX(12), PCUT(12), TARGET(12), EPSI(3),
         CUTF(12), TOBCUT(12)

-- File SUM.CMB was created on 08:51 24-09-91 as TREE2 was broken apart.

    COMMON /SUM/TOTSTM(12), TOTBA(12), TOTVOL(12), TOTDBH(12)

-- File WTHR1.CMB taken from DAMAGE.FOR 11/21/89

    COMMON /WTHR1/TFAC, TRETIR, DBGDT, ANNDD(100)
Location of common blocks, i.e., the routines in which they are included through use of an `INCLUDE` statement.

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*U.S. GOVERNMENT PRINTING OFFICE: 1995-652-758*