LANDIS-II Biomass Succession v7.0 Extension User Guide

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1 Introduction

This document describes the **Biomass Succession** extension for the LANDIS-II model. For information about the LANDIS-II model and its core concepts including succession, see the *LANDIS-II Conceptual Model Description.*

The Biomass Succession extension generally follows the methods outlined in Scheller and Mladenoff (2004). Biomass Succession calculates how cohorts reproduce, age, and die. In addition, changes in cohort biomass (g m^{-2}) are simulated. The Biomass Succession extension tracks dead biomass over time, divided into two pools: woody and leaf litter.

The Biomass Succession extension was designed to use a temporarily dynamic input file for **three** critical parameters (maximum biomass, maximum growth rate, and probability of establishment). These inputs are by species and by ecoregion. These data can be updated at any time step (see Chapter 3 below). For example, loblolly pine establishment could vary spatially (by ecoregion) and these data could be updated every 5 years into the future corresponding to climate change. The user is responsible for supplying these data. Other extensions (e.g., PnET and NECN) calculate many of these variables internally (for each species, ecoregion, and time step).

1.1 Extension Description

1.1.1 Cohort reproduction – disturbance interactions

Recall that every disturbance will trigger succession at each site at the time step that the disturbance(s) occur. In succession, there is a hierarchy of reproduction options following a disturbance. The goal of this design was to give reproductive precedence to species with propagules available on site.

If planting (currently possible only through a Harvest extension) is triggered for one or more species, then no other reproduction will occur. Planting is given highest precedence as we assume that a viable cohort is generated. However, the probability of establishment must be greater than zero.

If serotiny (only possible immediately following a fire) is triggered for one or more species, then neither resprouting nor seeding will occur. Serotiny is given precedence over resprouting as it typically has a higher threshold for success than resprouting. This slightly favors serotinous species when mixed with species able to resprout following a fire.

If resprouting (which can be induced by many disturbance types) is triggered, then seeding will not occur.

Finally, if neither planting, serotiny, nor resprouting occurred, seeding dispersal into a sight will occur.

1.1.2 Cohort reproduction – Initial biomass

Cohort reproduction is the establishment of a cohort, aged 1 year and the calculation of its initial biomass.

$$InitialBiomass = ANPP_{MAXi} \times Exp\left(-1.6 \times B_{SUM} / B_{MAX-ECOREGION}\right)$$

where $ANPP_{MAXi}$ is the maximum ANPP possible for the species *i;* $B_{MAX\text{-}ECOREGION}$ is the maximum biomass possible for the *ecoregion*; and B_{SUM} is the current total biomass for the site (not including other new cohorts). Initial biomass must be ≥ 1 (g / m^2); if < 1, initial biomass is set equal to 1.

Note: *This initial cohort will be grouped ('binned') appropriately into a larger cohort (e.g., 1 – 10) at the next successional time step.*

1.1.3 Cohort growth and ageing

Cohort net growth is based on the principles outlined in Scheller and Mladenoff (2004). Cohort net growth takes into consideration the age of the cohort, species, ecoregion, and competition. Cohort net growth is gross growth minus development-related mortality. **Cohort growth occurs at an annual time step, regardless of the overall extension time step.**

Competition and age reduce the maximum cohort biomass (B_{MAX}). Competition occurs when a stand contains more than one cohort. The potential biomass (B_{POT}) represents the available 'growing space', minus space already occupied by other species age cohorts. There are two alternative calculations for B_{POT}; the maximum of the two is used in subsequent calculations. The first estimates potential discounting space occupied by all cohorts:

$$B_{POTij} = \max\left[0, B_{MAXi} - \sum_{1}^{i}\sum_{1}^{j} B_{ij}\right] \qquad (1)$$

where i is species, j is age cohort. B_{ij} is the biomass for a single cohort. (This equation is a correction to the original found in Scheller and Mladenoff, 2004.) The second formulation was added to allow any recent non-disturbance mortality (i.e., from cohort senescence) to contribute to growing space. The purpose of the second formulation is to allow young cohorts some growing space as may be generated by within-cell gap-phase dynamics. For example, individual trees within an older cohort are dying due to old-age. Those gaps create growing space for younger cohorts.

$$B_{POTij} = \mathrm{Pr}\,evYearMortality \qquad (2)$$

where *PrevYearMortality* is all non-disturbance related mortality at the site during the previous year.

Note: *In the biomass succession extension, growth operates at an annual time step, regardless of the overall extension time step. Therefore,* PrevYearMortality *is literally from the previous year, not the previous extension time step.*

As of v3.0, competition (C_{ij}) is expressed as measure of cohort biomass compared to other biomass on the site. If there are no other cohorts on the site, the competition index is equal to 1.0.

$$C_{ij} = \frac{B_{ij}^{0.95}}{\sum_{ij} B_{ik}^{0.95}} \qquad (3)$$

Note: *In versions earlier than 3.0, competition was simply the ratio of B_{POTij} to B_{MAXi} (B_{PMij}).*

Next, the effect of development is calculated. This is a limit to productivity due to the biomass of a cohort relative to its maximum, i.e., a very young or small cohort is not as productive as a large, mature cohort:

$$DevelopmentLimit = e^{1} B_{APij}{}^{S} e^{-(B_{APij}{}^{S})} \qquad (4)$$

where B_{APij} is the ratio of cohort biomass (B_{ij}) to cohort potential (B_{POTij}), and S is the growth shape parameter. The growth shape parameter was added at v3.0, and previous versions functioned as if $S = 1$. Finally, the actual biomass for a cohort is calculated:

$$ANPP_{ACTij} = ANPP_{MAXi} \times DevelopmentLimit \times C_{ij} \qquad (5)$$

Cohort net biomass change is net growth minus mortality. Mortality is caused by senescence (below) and 'development'. Development mortality (M_{BIOij}) is the ongoing loss of individual trees and branches. It does not include leaf litter. Development mortality is low when a cohort is young or small, accelerates during the stem-exclusion phase (between young and mature ages), and plateaus at maturity. It is also constrained by maximum biomass and competition to ensure that is appropriate relative to a cohort's growth. As of v3.0, the equation for M_{BIO} has changed. If $B_{APij} > 1$, then $M_{BIOij} = ANPP_{MAXi} * B_{PMij}$. If $B_{APij} \leq 1$ then:

$$M_{BIOij} = ANPP_{MAXi} \times \frac{2 \times B_{APij}}{(1 + B_{APij})} \times B_{PMij} \quad (6)$$

Cohort ageing is simply the addition of the time step to each existing cohort.

1.1.4 Cohort senescence and mortality

As a cohort nears its longevity age, there will be an increase in the loss of biomass. This is called **age-related mortality**, and the age at which this mortality begins to be a factor is species-specific and controlled by the user. The biomass will decline to near zero at the maximum life span.

If a cohort exceeds the longevity for that species, then the cohort dies.

Beginning in v6, there is also now a random mortality per time step, per species, per ecoregion. This **probability of mortality** can reflect drought or other conditions related to climate or other ecoregion circumstances (see Krechun et al. 2020). The probability of mortality is applied to all cohorts of a species and ecoregion combination, regardless of age. The probability of mortality is compared against a uniform random distribution to determine whether cohort mortality occurs.

1.1.5 Dead biomass decay

When a cohort dies and is not consumed by a mortality agent (e.g., fire or harvest), its biomass is added to one or both of the two dead biomass pools: **woody** and **leaf**.

There is a mean decay rate for each pool at each site, determined by using a weighted average (weighted by mass) of the new dead material decay rate (user-determined) and the existing pool decay rate.

Disturbances can alter the dead biomass pools. They can add dead biomass (e.g., wind) and/or remove dead biomass (e.g., fire will add some woody dead biomass and remove all leaf dead biomass).

1.1.6 Initializing biomass

Beginning with v7, the user supplied initial biomass estimates from the initial communities file determines the amount of biomass on each site. Therefore, **there is no 'spin up' period**.

As a result, initial dead wood biomass and fine fuel biomass will be underestimated. V7.1 (under development) will allow for the optional inclusion of initial dead and fine fuel biomass maps.

1.1.7 Shade calculations

There are six possible site shade classes ranging from zero (no shade) to 5 (highest shade). Site shade is calculated based on the percentage of biomass present on a site relative to the maximum possible biomass for an ecoregion. The highest percentage allowed is 100%. The maximum possible biomass for an ecoregion is the maximum of all species maximum biomass (from the list of maximum biomass by species and ecoregion provided by the user).

User Tip: *If a species cannot occur in an ecoregion (e.g., establishment probability = 0.0), set the species maximum biomass to 0 for that species and ecoregion. This will ensure that the species doesn't influence the shade calculation for that ecoregion.*

A site will remain shade class 0 until the minimum percent biomass for shade class 1 is reached. Likewise, the site will be assigned shade class 1 until the percentage for shade class 2 is reached.

For example: If the maximum possible biomass for a site is 1000 (units are arbitrary) and the actual total site biomass is 550, the resulting percentage is 55%. The function for calculating shade progresses from lowest to highest shade class. If the user lists shade class 3 = 45% and shade class 4 = 60%, then the shade class assigned to the site will be 3.

User Tip: *If you want to limit the highest shade class assigned, as may be the case if an ecoregion never achieves 'closed canopy' conditions, assign a 100% value to a lower shade class. For example, if you want to limit assigned shade classes to 4 or less, then set shade class 4 = 100% and shade class 5 = 100%. When shade is being calculated, shade class 4 will meet its requirement before shade class*

5. The function that calculates shade class will therefore assign shade class 4 to the site.

Note: *The calculation of shade class is independent of any growth calculations***.**

1.2 Major Releases

1.2.1 Version 7.0 (September 2024)

A number of significant updates are included with v7:

- Update to Core v8.
- Update to Climate Library v5 (now required)
- Initial biomass determined by the initial community input

1.2.2 Version 6.0 (May 2021)

Beginning in v6, there is also now a random mortality per time step, per species, per ecoregion. This **probability of mortality** can reflect drought or other conditions related to climate or other ecoregion circumstances. The probability of mortality is applied to all cohorts of a species and ecoregion combination, regardless of age. The probability of mortality is compared against a uniform random distribution to determine whether cohort mortality occurs.

In addition, the species table and species-ecoregion table have been converted to csv formats.

1.2.3 Version 5.3 (March 2021)

Updated to Climate Library v4.2.

1.2.4 Version 5.2 (September 2019)

Updated to Succession Library v8 and Climate Library v4.

1.2.5 Version 5.1 (March 2019)

Updated to Succession Library v7.

1.2.6 Version 5.0 (August 2018)

Biomass Succession was recompiled for Core v7.0. In addition, the separate age-only-disturbance input text file was replaced with FireReductionParameters and HarvestReductionParameters tables in the primary input file. Doing so eliminated confusion regarding default behavior and simplified the code.

1.2.7 Version 4.0 (June 2017)

Added PartialCohortMortality interface to fix error whereby partial cohort mortality (particularly from Biomass Harvest) was not properly allocating dead material.

Access to the Climate Library was also added. This enables a suite of LANDIS-II model extensions to use the same stream of climate data (see the climate library user's manual (LANDIS-II Climate Library v1.0 User Guide). By feeding in climate data only once, the climate is seamlessly integrated across all extensions specified in the scenario file. As outlined in the Climate Library User's Guide, the user can feed in daily or monthly data without having to calculate standard deviation.

1.2.8 Older Versions

Documentation for versions 3.x and earlier can be found on GitHub:

https://github.com/LANDIS-II-Foundation/Extension-Biomass-Succession/tree/master/docs

1.3 Minor Releases (this major release)

1.4 References

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1.5 Acknowledgments

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2 Succession Input File

Nearly all the input parameters for this extension are specified in one main input file. This text file must comply with the general format requirements described in section 3.1 *Text Input Files* in the *LANDIS-II Model User Guide*.

2.1 LandisData

This parameter's value must be `"Biomass Succession"`.

2.2 Timestep

This parameter is the timestep of the extension. Value: integer > 0. Units: years.

2.3 SeedingAlgorithm

This parameter is the seeding algorithm to be used. Valid values are `"WardSeedDispersal"`, `"NoDispersal"` or `"UniversalDispersal"`. The algorithms are described in section 4.5.1 *Seeding* of the *LANDIS-II Conceptual Model Description*.

2.4 InitialCommunities

This parameter is the file with the definitions of the initial communities at the active sites on the landscape (see chapter 4).

2.5 InitialCommunitiesMap

This parameter is the input map indicating the initial communities at the active sites on the landscape. Each cell value for an active site on the landscape must be one of the map codes listed in the initial communities input file (see chapter 4).

2.6 ClimateConfigFile (Required)

The climate configuration file contains required climatic inputs. The format of that file and its contents are described in the climate library user's manual (LANDIS-II Climate Library v5.0 User Guide). **This parameter is required**.

2.7 CalibrateMode

An **optional parameter**, CalibrateMode determines whether additional log file data is activated. Input = 'yes' or 'no' or Y or N.

2.8 MinRelativeBiomass Table

This table contains the minimum relative biomass for shade classes 1 - 5.

2.8.1 First Row – Ecoregions

The first row in the table is a list of all the active ecoregions defined in the ecoregions input file (see chapter 6 in the *LANDIS-II Model User Guide*. The ecoregions can appear in any order; they do not need to appear in the same order as in the ecoregions input file.

2.8.2 Other Rows

There are 5 other rows in the table, one row for each shade class.

2.8.3 Shade Class

This column contains shade class values: $1 \leq$ integer ≤ 5. The shade classes must be in increasing order: class 1 first and ending with class 5. Shade class 5 represents the most shade. A site will be shade class 0 (no shade) until the minimum relative biomass for shade class 1 is reached.

2.8.4 Minimum Biomass Percentage per Ecoregion

Each ecoregion listed in the table's first row (see section 2.9.1) must have a separate column of minimum biomass by shade class. The percentages represent the lower threshold of biomass on a site relative to the ecoregion's maximum possible biomass (for any species) for the site to enter the shade class indicated in column 1. Sites with less than the lowest threshold value will be assigned to shade class 0 (full sunlight). The maximum biomass for an ecoregion is the maximum growth rate (for any species) multiplied by 30 (equation 2, Scheller and Mladenoff 2004). Value: $0.0 \leq$ decimal number ≤ 100.0. Units: percent.

2.9 SufficientLight Table

2.9.1 Species Shade Tolerance Class

This column contains shade class values: $1 \leq$ integer ≤ 5. The shade classes must be in increasing order: class 1 first and ending with class 5. Shade class 5 represents the most shade tolerant.

2.9.2 Probability of Establishment, given light conditions

Each possible site-level light condition (0 – 5) has an associated probability for each species shade tolerance class (1 – 5). Value: 0.0 ≤ decimal number ≤ 1.0.

2.10 SpeciesDataFile

This CSV file should contain the following column headers and data:

2.10.1 SpeciesCode (string)

The species must be defined in the species input file (see chapter 5 in the *LANDIS-II Model User Guide*). Species may appear in any order.

2.10.2 LeafLongevity (double)

This parameter is the average longevity of a leaf or needle. Value: 1.0 ≤ decimal number ≤ 10.0. Units: years.

2.10.3 WoodDecayRate (double)

This parameter, *k*, defines the rate (e^{-k}) at which the species' dead wood decomposes in the ecoregion. Value: 0.0 ≤ number ≤ 1.0. Unitless.

Decomposition is calculated according to Equation 7 in Scheller and Mladenoff (2004) such that Dead Biomass (t+1) = Dead Biomass(t)*e^-*k*. The time step in the equation is1 year, and the Biomass Extension correctly applies the formula regardless of the extension time step.

2.10.4 MortalityCurve (double)

This parameter determines how quickly age-related mortality begins. Value: 5.0 ≤ decimal number ≤ 25.0. If the parameter = 5, then age-related mortality will begin at 10% of life span. If the parameter = 25, then age-related mortality will begin at 85% of life span.

2.10.5 GrowthCurve (double)

This parameter determines how quickly ANPP reaches its maximum. Value: 0.0 ≤ decimal number ≤ 1.0. A value of 1.0 is the slowest increase in ANPP and reflects the assumptions of all previous Biomass Succession extensions. As the value become smaller, ANPP will reach maximum at a faster rate.

2.10.6 LeafLignin (double)

The percent leaf lignin per species. Value: 0.0 ≤ decimal number ≤ 1.0.

2.11 EcoregionParameters Table

2.11.1 First Column – Ecoregions

The first column in the table is a list of one or more active ecoregions defined in the ecoregions input file (see chapter 6 in the *LANDIS-II Model User Guide*). The ecoregions can appear in any order; they do not need to appear in the same order as in the ecoregions input file.

2.11.2 Actual Evapotranspiration (AET)

Used to determine decay rates for leaf decomposition. Value: 0 ≤ integer number ≤ 10,000 (Note: the value is typically < 1000). Units: mm.

2.12 SpeciesEcoregionDataFile

This CSV file should contain the following column headers and data:

2.12.1 Year (integer)

The year that the parameters change. Value: integer.

A year expression represents the time step. **Values for time step zero are required.**

2.12.2 EcoregionName (string)

An active ecoregion defined in the ecoregions input file (see chapter 6 in the *LANDIS-II Model User Guide*). The ecoregions can appear in any order; they do not need to appear in the same order as in the ecoregions input file.

Every active ecoregion that is not listed will have default parameter values assigned to all the species (given below).

2.12.3 SpeciesCode (string)

The species can be listed in any order in a table. A species can be omitted. If so, it will be assigned the default parameter value for all active ecoregions.

2.12.4 ProbEstablish (double)

The probability that the species establishes in the ecoregion. Value: 0.0 ≤ decimal number ≤ 1.0. Default value: 0.0.

2.12.5 ProbMortality (double)

The probability that a cohort in the ecoregion dies. Value: 0.0 ≤ decimal number ≤ 1.0. Default value: 0.0.

2.12.6 ANPPmax (integer)

The maximum possible aboveground net primary productivity (ANPP) for the species in the ecoregion. Value: 0 ≤ integer ≤ 100,000. Units:

New: The units must be **g biomass / m^2 / year**. Default value: 0

2.12.7 BiomassMax (integer)

The maximum allowable aboveground biomass (AGB) for the species in the ecoregion. Value: 0 ≤ integer. The units must be **g biomass / m^2**. Default value: 0.

2.13 Fire Reduction Parameters

The `FireReductionParameters` table allows users to specify how much dead wood and litter will be removed as a function of fire severity. The reduction of wood and litter will occur **after** fire induced mortality of cohorts. After a fire kills a cohort, the dead biomass is deposited on the forest floor and is then subsequently volatilized in the same time step.

Note: This table is required even if fire extensions are not being used.

2.13.1 Fire Severity

The first column is fire severity, classes 1 – 5. Severity should be listed in ascending order.

2.13.2 Wood Reduction

The second column is the proportion (0.0 – 1.0) of dead wood biomass that is volatilized. The proportion will be applied to both C and N components.

2.13.3 Litter Reduction

The third column is the proportion (0.0 – 1.0) of dead litter biomass that is volatilized. The proportion will be applied to both C and N components.

2.14 Harvest Reduction Parameters

The `HarvestReductionParameters` table specifies how much dead wood and litter will be removed as a function of harvest activity ***and how much cohort wood and leaf biomass is moved off site during harvesting***. Cohort wood is typically removed from the site during harvesting. The reduction of dead wood and litter will occur **after** harvest induced mortality of cohorts. After a harvest event kills a cohort, the dead biomass is removed from the forest. If a prescription is not listed (or is not spelled identically to the name used in the harvest prescription file), the defaults are zero for all values.

2.14.1 Prescription Name

The first column is prescription name. Each prescription name must be identical to the prescription names in the Leaf Biomass Harvest file (see "LANDIS-II Base Harvest v2.0 User Guide"). Prescriptions can be in any order; they do *not* need to appear in the same order as in the Harvest extension input file.

Beginning with v5.2.1, prescription names can contain wildcards ('*'). For example, the prescription name 'Patch*' would work with harvest prescriptions 'PatchCutting' or 'PatchCutMaple'. The asterisk must be at the end of the prescription name.

2.14.2 Dead Wood Reduction

The second column is the proportion (0.0 – 1.0) of dead wood biomass that is removed. This is dead wood that existed prior to harvesting.

2.14.3 Dead Litter Reduction

The third column is the proportion (0.0 – 1.0) of dead litter biomass that is removed. This is litter that existed prior to harvesting.

2.14.4 Cohort Wood Removal

The fourth column is the proportion (0.0 – 1.0) of harvested cohort *live wood* biomass that is removed from the site. *The remainder is typically regarded as slash, e.g., branches or other non-economically valuable wood.*

2.14.5 Cohort Leaf Removal

The last column is the proportion (0.0 – 1.0) of harvested cohort *live leaf* biomass that is removed from the site. *The remainder is typically regarded as slash. In a typical harvest situation, 0.0 is removed from the site. The exception would be some form of biomass harvest.*

3 Initial Communities

This file contains the definitions of the initial community classes. Each active site on the landscape is assigned to an initial community class. The class specifies the tree species that are present along with the particular age classes that are present for each of those species.

3.1 Initial Communities Map

This is the input map indicating the initial communities at the active sites on the landscape. Each cell value for an active site on the landscape must be one of the map codes listed in the initial communities input file.

Each initial community has an associated map code and a list of species present at sites in the class. There is **now only one input format**, a CSV file, described below.

3.2 Initial Communities Input CSV File

This file contains the definitions for each initial community. Each active site on the landscape is assigned an initial community. The initial community specifies the cohorts that are present including species, age, and biomass (g m^{-2}). Each initial community has an associated map code that corresponds to the accompanying map. Note: ANPP (g m^{-2} yr^{-1}) is initialized with a value of 0 and is assigned a value during the first time step.

3.2.1 FileName

The file name must point to a CSV file with format described next.

3.2.2 CSV file format

The CSV format requires a header with the following names: X, Y, Z.

Each row contains these data:

MapCode: This parameter is the code used for the community in the input map (see section 2.5). Value: $0 \leq$ integer $\leq 65,535$. Each communities' map code must be unique. Map codes do not have to appear in any order, and do not need to be consecutive.

SpeciesName: These must match the names found in the scenario species file.

CohortAge: A cohort age is an integer and must be between 1 and the species' Longevity parameter. The ages do not have to appear in any order.

CohortBiomass: Biomass must be entered as an integer (no significant digits).

For Empty Map Codes: If there is an active map code that does not have any vegetation, the data should be represented as: *TheActualMapCode*, NA, 0, 0 (where *TheActualMapCode* is the code without data, e.g. 1968).

3.2.3 Grouping Species Ages into Cohorts

The list of ages for each species is grouped into cohorts based on the succession extension's timestep. This timestep determines the size of each cohort. For example, if the timestep is 20, then the cohorts are ages 1 to 20, 21 to 40, 41 to 60, etc.

Suppose an initial community class has this species in its list (biomass left out here for simplicity):

```
acersacc  10  25  30  40  183  200
```

If the succession timestep is 10, then the cohorts for this species initially at each site in this class should be:

```
acersacc  10  20  30  40  190  200
```

Note that biomass values will be totaled when cohorts are grouped.

If the succession timestep is 20, then the cohorts for this species initially at each site in this class will be:

```
acersacc  20  40  200
```

4 Outputs

For every time step, raster maps of aboveground biomass Annual Net Primary Productivity (ANPP) (g m $^{-2 - yr}$) are produced. In addition, a comma-delimited log file is automatically generated with the name **Biomass-succession-v3-log.csv**. There are six columns of data, listed below.

4.1.1 Time

The simulation time step

4.1.2 Ecoregion

The ecoregion reported. Columns 4-6 are ecoregion averages for the time step.

4.1.3 NumSites

The number of active sites per ecoregion. This column allows rapid calculations of totals as columns 4-6 are area adjusted.

4.1.4 LiveB

The total aboveground live biomass (g m^{-2}) averaged across all sites in the ecoregion.

4.1.5 AG_NPP

The total aboveground biomass net primary productivity (g m^{-2} yr^{-1}) averaged across all sites in the ecoregion.

4.1.6 LitterB

The total aboveground litter biomass (g m^{-2}) averaged across all sites in the ecoregion. Dead woody biomass is not included.

5 Example Inputs

5.1 Main Parameter File

```
LandisData  "Biomass Succession"

Timestep  10

SeedingAlgorithm  WardSeedDispersal
>> Also NoDispersal or UniversalDispersal

 InitialCommunities      "./initial-communities.txt"
 InitialCommunitiesMap   "initial communities.gis"

 ClimateConfigFile   ./ClimateGenerator.txt  << optional

CalibrateMode no  << optional parameter

SpinupMortalityFraction 0.001  << optional parameter

>> *********************
   MinRelativeBiomass

>> Shade
>> Class     Ecoregions
>> -----     ------------
             eco1    eco2

     1       25%     20%
     2       35%     30%
     3       45%     40%
     4       60%     50%
     5       95%     80%

>> ***************************
SufficientLight
>> Spp Shade   Probability
>> Class       by Actual Shade
>> ----------  --------------------
>>             0     1     2     3     4     5
   1           1.0   0.0   0.0   0.0   0.0   0.0
   2           1.0   1.0   0.0   0.0   0.0   0.0
   3           1.0   1.0   1.0   0.0   0.0   0.0
   4           1.0   1.0   1.0   1.0   0.0   0.0
   5           0.0   0.0   1.0   1.0   1.0   1.0

>> *************************************************
SpeciesDataFile SppData.csv

>> ***************************
```

```
EcoregionParameters
>>      AET
>>      mm
eco1    600
eco2    600

SpeciesEcoregionDataFile   SppEcoregionData.csv

FireReductionParameters  << You can include up to
>> severity = 5
>> Severity    WoodLitter  Litter
>> Fire        Reduct      Reduct
   1           0.0         0.5
   2           0.0         0.75
   3           0.0         1.0

HarvestReductionParameters
>> Name  Wood        Leaf        Cohort      Cohort
>>       Reduct      Reduct      WoodRemove  LeafRemove
MaxAgeClearcut 0.5   0.15        0.8         0.0
PatchCutting   1.0   1.0         1.0         0.0
```