Drought Generator and Drought Disturbance Extensions (v1.0) Combined User Guide

LANDIS-II Extensions

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1   Introduction

This document describes the **Drought Generator Extension** for use with the LANDIS-II model. For information about the model and its core concepts, see the *LANDIS-II Conceptual Model Description.*

1.1 Version 1.0

Version 1.0 is compatible with LANDIS-II v6.0.

1.2 Extension Description

1.2.1 Overview

This extension generates a site-level variable representing a user-chosen measure of drought conditions. Examples of such a drought variable include average length of drought events, average drought severity, mean Palmer Drought Severity Index per decade. The variable is updated at each time step. The variable is given a user-defined name and made available for other extensions to use. The original intent of this extension is to provide information used by the Drought Disturbance Extension.

1.2.2 Drought Variable

The extension draws a value of the drought variable from a lognormal distribution. The user must provide Mu and Sigma values that define the lognormal distribution of the drought variable selected.

For each timestep, a value for the drought variable is stochastically drawn from the lognormal distribution. The user can choose any drought variable when estimating the parameters of the lognormal distribution, but the Drought Generator extension requires no information about the variable other than the two parameters defining the lognormal distribution of that variable. The user should ensure that the values generated by those lognormal parameters are consistent with the extension timestep parameter. The value of the variable is recorded as a site variable that is available to all other extensions. The user provides a name for the drought variable, which ensures that other extensions (e.g. Drought Disturbance) use the correct drought variable.

1.3 References

Gustafson, E.J., B.R. Sturtevant. In Press. Assessing the spatial and temporal scale of forest mortality from drought stress: implications for climate change. Ecosystems.

1.4 Acknowledgments

2 Parameter Input File

The input parameters for this extension are specified in a single 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 `"Drought Generator"`.

2.2 Timestep

This parameter is the extension's timestep. A new value of the drought variable is generated at each timestep. Value: integer > 0. Units: years.

2.3 VariableName

This parameter determines how the site variable stored from this extension will be identified for use by other extensions. The VariableName provided here must match exactly with the variable name provided in other extensions intending to access the site variable.

2.4 Mu

This parameter defines the Mu parameter of the lognormal distribution of the drought variable. Value: Any Real Number.

2.5 Sigma

This parameter defines the Sigma parameter of the lognormal distribution of drought years per decade. Value: Real$\geq$0.0.

2.6 LogFile

The file parameter is the name of the extension's event log file (see section 3.2).

3 Output Files

The drought generator extension generates two types of output files: a) a map of number of drought years per decade for each time step, and b) a log of drought years for the entire scenario.

3.1 Drought Generator Log

The log is a text file that contains information about the generated variable values for each timestep over the course of the scenario. The information is stored as comma-separated values (CSV).

4 Example File

```
LandisData "Drought Generator"


Timestep  10


VariableName  "Drought.Years"
Mu  1.0
Sigma 0.6


MapName  "drought/DY-{timestep}.img"


LogFile  "drought/droughtgen-log.txt"
```

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Table of Contents

1   Introduction

This document describes the **Drought Disturbance Extension** for use with the LANDIS-II model. This extension is dependent on the **Drought Generator Extension**, and must be run with a Biomass Succession version that includes establishment modification (i.e., v3.1). For information about the model and its core concepts, see the *LANDIS-II Conceptual Model Description.*

1.1 Version 1.0

Version 1.0 is compatible with LANDIS-II v6.0, Drought Generator Extension v1.0, and Biomass Succession v3.1.

1.2 Extension Description

1.2.1 Overview

This extension models biomass removal, cohort mortality, and reduced establishment caused by drought conditions that are supplied by the Drought Generator Extension. A proportion of the biomass of each species on a cell is removed and probability of establishment is modified as a function of drought conditions.

1.2.2 Drought Variable

The extension uses a drought variable (e.g., average length of droughts) provided by the Drought Generator Extension. The user specifies the name of the drought variable, which must match the variable name from the Drought Generator Extension. The user can specify a minimum value for this variable, below which drought has no impact on biomass, mortality or establishment. Similarly, the user can provide a maximum value for this variable such that values greater than this value will be re-assigned to this value. This is useful when coefficients (see below) may generate spurious values when extrapolated beyond values used to build the regression models.

1.2.3 Biomass Removal

The removal of biomass from cohorts depends on the drought variable and on the specific species. The loss of biomass to mortality for a species is calculated from species specific inputs that define the relationship between the drought variable and the proportion of biomass lost to mortality (*pm*). The user supplies estimates for the

intercept and slope of this relationship, along with standard errors for each parameter estimate. At each timestep these parameters are used to generate a range (95% confidence interval) of *pm* based on the value of the drought variable. For each active cell on the landscape, and for each species on the cell, a value for *pm* is selected from the confidence interval using the age of the oldest cohort (calculated as a percent of the species longevity) as an index to specify a location between the lower and upper bounds of the confidence interval. Thus, cells with oldest cohorts nearer longevity age will have a *pm* value found in the upper part of the confidence interval while cells with younger oldest cohorts will have a *pm* value found in lower portions.

As an illustration, consider this example. Say that the range (confidence interval) of *pm* calculated from the drought variable for species X is 0.08-0.22. For a cell on which the oldest cohort of species X is at 99% of its longevity, the *pm* value applied to that species would be close to 0.22. If the oldest cohort was only 50% of its longevity, the *pm* value applied to that species would be 0.15.

Once *pm* has been calculated for a given species, the appropriate amount of biomass is removed starting with the oldest cohort. Cohorts are completely or partially removed until the target amount of biomass is removed. If the amount of biomass to be removed from a cohort is > 90% of the cohort's total biomass, the entire cohort is removed. The cohort is considered killed when all of its biomass is removed.

1.2.4 Establishment Modification

Drought also can modify the probability of establishment **for the current timestep only**. The user specifies a drought sensitivity class (1-3) for each species, which determines the influence drought has on seedlings. Class 1 is insensitive to drought and the probability of establishment is not modified. Class 2 is moderately sensitive to drought and the probability of establishment is reduced by 50%. Class 3 is sensitive to drought and the probability of establishment is reduced by 100%. Establishment modifications only occur if the drought variable exceeds the minimum threshold, and the modifications are only applied to a single succession timestep. Therefore it is important that the drought extensions and the succession extension be run with the same timestep.

1.3 References

Gustafson, E.J., B.R. Sturtevant. In Press. Assessing the spatial and temporal scale of forest mortality from drought stress: implications for climate change. Ecosystems.

1.4 Acknowledgments

Brian Sturtevant contributed to the design of this extension.

2 Parameter Input File

The input parameters for this extension are specified in one 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 "Drought Disturbance".

2.2 Timestep

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

2.3 VariableName

This parameter identifies the site variable provided by the Drought Generator extension. The VariableName provided here must match exactly with the variable name provided by the generator extension.

2.4 MinDroughtVar

This parameter defines the minimum value of the drought variable that is required for drought to have any impact on biomass or establishment. Value: Any Real Number

2.5 MaxDroughtVar

This parameter defines the maximum value of the drought variable that is allowed for calculation of the proportion of biomass lost to mortality. Values above this value are re-assigned to be equal to this value. Value: Any Real Number

2.6 BackTransformation

This parameter specifies the nature of any required backtransformation of the proportion of biomass lost to mortality calculated using the regression coefficients supplied in the SpeciesParameters table (below). The EXP backtransformation uses $pm = EXP(y + \beta x)$ where y is the intercept, β is the slope and x is the drought variable. The SQUARE backtransformation uses $pm = (y + \beta x)^2$ Valid values: NONE, EXP, SQUARE.

2.7 InterceptCorrection

This parameter specifies if the *pm* values should be reduced by the amount of the intercept. This is useful to eliminate background mortality that may be present in the mortality functions. The extension subtracts the value of the function when the drought variable is zero from the value calculated using the value of the drought variable that was supplied by the Drought generator. Valid values: Y, N.

2.8 SpeciesParameters

This table defines the intercept (Y), intercept standard error (Y_SE), slope (B), slope standard error (B_SE) and drought sensitivity for each species. The intercept and slope parameter define the relationship between drought variable and proportion of biomass lost to mortality. The standard error terms are used to calculate confidence intervals. The drought sensitivity class (1-3) determines the relative sensitivity of seedlings to drought.

2.9 MapName

This file parameter is the template for the names of the drought biomass removed output map. The parameter value must include the variable "**timestep**" to ensure that the maps have unique names (see section 3.1.8.1 *Variables* in the *LANDIS-II Model User Guide*). The user must indicate the file extension. The user must also include sub-directory name(s) as needed.

2.10 LogFile

The file parameter is the name of the extension's log file (see section 3.2).

3 Output Files

The drought disturbance extension generates two types of output files: a) a map of the biomass removed for each time step, and b) a log of biomass removed by species for each timestep for the entire scenario.

3.1 Drought Biomass Removed Maps

The map of drought biomass removed represents the amount of biomass (across all species) that was removed because of drought. Non-active sites have a value of 0 in all maps. A map is produced for each drought disturbance time step.

3.2 Drought Disturbance Log

The log is a text file that contains information about the biomass removed for each species for each timestep over the course of the scenario. The log includes columns for the drought variable, biomass removed for each species, total biomass removed across all species, number of cohorts killed for each species, total cohorts killed across all species, and the extra biomass removed for each species. Extra biomass is the additional biomass that is removed when a cohort that has >90% of its biomass targeted for removal, and is instead completely removed. The information is stored as comma-separated values (CSV).

4 Example File

```
LandisData "Drought Disturbance"


Timestep 10


VariableName  "Drought.Years"
MinDroughtVar 1
MaxDroughtVar 5


BackTransformation EXP  << NONE, EXP, SQUARE


InterceptCorrection Y  << Y,N


SpeciesParameters
>>                              Seedling
>>           Intcpt      Slope   Drought
>>SppName   Y   Y_SE    B   B_SE  Sensitivity
>>-------------------------------------------
abiebal  -4.426 0.037 0.235 0.019   2
acerrub  -5.668 0.031 0.258 0.016   2
acersac  -5.668 0.031 0.258 0.016   2
betuall  -4.426 0.037 0.235 0.019   3
betupap  -5.499 0.028 0.576 0.015   2
fraxame  -5.668 0.031 0.258 0.016   2
fraxnig  -5.499 0.028 0.576 0.015   3
larilar  -5.668 0.031 0.258 0.016   2
picegla  -4.426 0.037 0.235 0.019   2
picemar  -5.668 0.031 0.258 0.016   2
pinuban  -25.00 0.000 0.000 0.000   2
```

```
pinures  -25.00 0.000 0.000 0.000   2
pinustr  -25.00 0.000 0.000 0.000   2
popugra  -5.499 0.028 0.576 0.015   2
poputre  -5.499 0.028 0.576 0.015   2
prunser  -5.668 0.031 0.258 0.016   2
queralb  -25.00 0.000 0.000 0.000   2
querell  -25.00 0.000 0.000 0.000   2
querrub  -25.00 0.000 0.000 0.000   2
thujocc  -4.426 0.037 0.235 0.019   3
tiliame  -5.668 0.031 0.258 0.016   2
tsugcan  -4.426 0.037 0.235 0.019   3
>>-------------------------------------

MapName "drought/droughtbiorem-{timestep}.gis"


LogFile "drought/droughtdist-log.csv"
```