Drought Disturbance Extension (v1.0) User Guide

LANDIS-II Extension

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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, mortality, and reduced establishment caused by drought conditions that are supplied by the Drought Generator Extension.

1.2.2 Drought Years

The extension uses the number of drought years per decade provided by the Drought Generator Extension. The user can specify a minimum number of drought years below which drought has no impact on biomass, mortality or establishment.

1.2.3 Biomass Removal

The removal of biomass from cohorts depends on the length of drought (number of drought years per decade) and on the specific species. The predicted percent mortality for a species is calculated from species specific inputs that define the relationship between the predictor (number of drought years) and the response (percent mortality). Users supply estimates for the intercept and slope of this relationship, along with standard errors for each parameter estimate. These parameters are used to generate a range (95% confidence interval) of mortality values based on the number of drought years for the timestep. The actual value used is selected from within that range based on the age of the oldest cohort of the species. The closer the oldest cohort is to its longevity age, the greater the resulting percent mortality.

As an illustration, consider this example. Say that the range (confidence interval) of predicted mortality rate calculated from number of drought years 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 percent mortality applied to that species would be close to 0.22. If the oldest cohort was only 50% of its longevity, the percent mortality applied to that species would be 0.15.

Once the percent mortality 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 removal of biomass can result in cohort mortality, but does not always.

1.2.4 Establishment Modification

The user specifies a drought sensitivity class (1-3) for each species, which determine the influence drought has on seedlings, which is reflected in reduced establishment. Class 1 is insensitive to drought and has no establishment modification. Class 2 is moderately sensitive to drought and has establishment reduced by 50%. Class 3 is sensitive to drought and has establishment reduced by 100%. Establishment modifications only occur if the number of drought years 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 prep. 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 MinDroughtYears

This parameter defines the minimum number of drought years per decade that are required for drought to have any impact on biomass or establishment. Value: $0 \leq integer \leq 10$. Units: years.

2.4 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 number of drought years and percent mortality. The drought sensitivity class (1-3) determine the relative sensitivity of seedlings to drought.

2.5 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.

2.6 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 Years per Decade Maps

The map of drought biomass removed represents the amount of biomass (across all species) that was removed due to 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 Generator 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 number of drought years (DroughtYrs), 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


MinDroughtYears  2


SpeciesParameters
<<SppName    Y      Y_SE     B     B_SE  Sensitivity
abiebals  -0.757  0.025  0.098  0.006  2
acerrubr  -1.460  0.045  0.088  0.011  2
acersacc  -1.224  0.044  0.061  0.011  2
betualle  -0.945  0.077  0.119  0.019  3
betupapy  -0.986  0.041  0.147  0.010  2
fraxamer  -1.360  0.063  0.086  0.016  2
piceglau  -0.757  0.025  0.098  0.006  2
pinubank  -0.789  0.062  0.122  0.015  2
pinuresi  -1.935  0.084  0.125  0.020  2
pinustro  -1.935  0.084  0.125  0.020  2
poputrem  -0.784  0.024  0.124  0.006  2
querelli  -1.590  0.221  0.093  0.073  2
querrubr  -1.490  0.095  0.115  0.026  2
thujocci  -1.511  0.059  0.089  0.014  2
tiliamer  -1.294  0.088  0.083  0.024  2
tsugcana  -1.186  0.103  0.041  0.026  3


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


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