LANDIS-II Dynamic Biomass Fuel System Extension v1.1 User Guide

Robert M. Scheller[1]

[1]Conservation Biology Institute

Last Revised: February 12, 2009

Table of Contents

1 Introduction

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

The **Dynamic Biomass Fuel System** extension described herein is identical to the **Dynamic Fuel System** except for the calculation of species values (see below). Specifically, this extension uses cohort biomass in addition to cohort age, conifer mortality, and post disturbance information at each site to classify every active site into a season-independent fuel type. **Therefore, it is necessary that a Biomass Succession extension is selected that calculates biomass for every cohort.**

This extension will produce maps of fuel types, percent conifer, and percent dead fir, and it produces four site variables that can be seen by all other extensions: fuel type, percent conifer, percent hardwood, and percent dead fir. Assigning active sites to fuel types is a required input for the external Dynamic Fire System extension, which utilizes fuel type classification in combination with seasonal and other parameters, to determine fire spread rates.

Both the Dynamic Biomass Fuel System and the Dynamic Fuel System work in conjunction with the Dynamic Fire System. Because of the need to have fuels and fire in close synchrony, this is a **disturbance extension** and **should be listed immediately prior to the Dynamic Fire System**.

1.1 What's New

In version 1.1 an optional ecoregion table was added that allows a user to limit fuel types to select ecoregions.

Note: The limiting ecoregions are the same as found in the main scenario file. *They are not the fire regions as defined in the Dynamic Fire System extension*.

1.2 Fuel Types

A fuel type can be defined as "an identifiable association of fuel elements of distinctive species, form, size, arrangement, and continuity that will exhibit characteristic fire behavior under defined burning conditions" (Merrill and Alexander 1987). For example, the Canadian Fire Prediction System fuel types are described qualitatively based on stand structure, composition, surface fuels, ladder fuels, and forest floor characteristics, including cover and duff (FBP; Forestry Canada Fire Danger Group 1992).

The LANDIS-II **Dynamic Biomass Fuel System** extension ('fuel extension' henceforth) allows up to 100 different fuel types, limited to the following base fuel types: Conifer, ConiferPlantation, Deciduous, Slash, and Open. The rules defined below determine which fuel type each site is assigned. These types – each given a numeric index – should match the fuel types and indices defined in the **Dynamic Fire System** extension. If a site is assigned a fuel type that is not listed in the Dynamic Fire System extension, the default values will be zero and fire will be unable to spread and burn across that site.

1.3 Fuel Classification

The fuels classification is determined by where a cohort falls within a fuel type age range. The formula is:

$$SpeciesValue = \sum_{0}^{n} Biomass \times SppCoefficient$$

where *Biomass* is the biomass (kg/ha) of all cohorts that falls within an age range (with a maximum and minimum) defined by the user; and *SppCoefficient* is a user specified weight (0 – 1.0) that can be assigned to each species (default = 0).

For each fuel type, these species values are summed (or subtracted if given the negative switch, see below), depending upon which species are listed for the fuel type. The fuel type with the highest overall score is assigned to the cell.

The species coefficient provides flexibility in determining the influence of a particular species on fire spread rates for mixedwood fuel types, and is a user input value ($0.0 \leq FC \leq 1.0$). Species coefficients are generally recommended at or near 1.0 (the default value) for all species. For instance, a fuel coefficient value of 0.95 for a particular conifer species in a mixedwood type can substantially reduce the relative conifer dominance for a site, in effect, giving more influence to the deciduous component on fire spread rates. If a deciduous species is assigned a *SppCoefficient* < 1.0, then the conifer component in a site with that species will have more influence on fire spread rates.

1.4 Conifer and Deciduous Dominance

Conifer and deciduous dominance (CD and DD, respectively) is used to determine if sites are initially assigned to either a coniferous, deciduous, or mixed-wood fuel type. The conifer dominance is calculated using the sum of dominance values for the two conifer base types (Conifer and ConiferPlantation). Deciduous dominance is the sum of dominance values for the Deciduous base type. To determine their respective types, each is divided by the sum of conifer plus deciduous dominance.

An optional, maximum percent hardwood (PH) “cut-off” value can be defined by the user that will determine whether sites containing both deciduous and coniferous species are placed into either coniferous or mixedwood fuel groups. The default maximum PH value for placement of a site into the coniferous fuel group category is 0% (i.e., CD = 1.0). Under this default setting, active sites that contain both deciduous and coniferous species (i.e., PH > 0%; CD < 1.0) are categorized as a mixed-wood fuel type, and fire spread rates will be calculated as a proportional “blend” of the deciduous and coniferous components (see equations 27 & 28 in the **Dynamic Fire Extension** Users Guide). However, a higher maximum PH value can be set by the user that will result in an active site containing both coniferous and deciduous species being placed into a coniferous or deciduous fuel type. This option might be desirable when the user wishes to prevent active sites from being categorized as a mixed-wood fuel type because either the deciduous or coniferous component is minor (e.g., a mature-conifer dominated site that contains one young-age cohort of a single deciduous species). The PH cut-off is also used to categorize mixed types as “pure” hardwoods. In this case, the CD must be greater than (100 – PH) to be classified as mixed. Therefore, when the PH value is > 0, then mixed types occur only when actual CD is between PH and (100 – PH). Caution should be used in setting the maximum PH value above the default value of zero (0), and interactions with the user-defined fuel coefficient set in the CD equation (1) should be carefully considered and tested.

1.5 Dead Conifer Index

To reflect the ladder-fuel effects of dead conifers in a stand understory, the Fuel Extension can apply an optional dead conifer index input from the external Base BDA Extension. The dead conifer index is based on the total number of dead fir and spruce cohorts relative to the total number of species cohorts at each site, with possible values ranging from 0 to 1. The dead conifer index lasts for a duration defined by the user, after which time the dead conifer index is reset to zero.

The dead conifer index input is applied to all mixed-wood and conifer fuel types, such that any dead conifer index value > 0 effectively alters the spread rate for any Conifer, Conifer Plantation, and any mixed fuel types (depending on the fire season input in the Fire Extension). However, note that a pre-existing conifer fuel type with a dead conifer index > 0 will only be converted to the Dead Balsam Fir (leaf off) fuel type, whereas the deciduous and boreal mixed-wood fuel types with a dead conifer index > 0 can be converted to a mixed fuel type. If the optional dead conifer index or the BDA Extension are not activated, the Fuel Extension will assign a default value of "no effect" for the dead conifer index.

1.6 Post Disturbance Information

To simulate the change in fuels following a disturbance, the fuels extension provides an option to assign an active site to a new fuel type. The user must also determine the duration (in number of years) for the conversion fuel types. These new fuel types can be any fuel listed in the Dynamic Fire System extension. After a stipulated number of years expire, the conversion fuel type is replaced by a new fuel type, based on other fuel extension inputs and parameters.

Because post-disturbance fuel types typically persist for only a few years after a disturbance. Unless fuels are arranged to occur after disturbance using the same time step, this short time frame requires setting yearly time steps in the Fuel Extension. However, post-disturbance fuel types could persist longer in drier climates, permitting longer time steps.

1.7 Acknowledgements

Funding for the development of this extension was provided by U.S. Forest Service Pacific Southwest Region in Sacramento, California. Funding for the development of LANDIS-II has been provided by the Northern Research Station (Rhinelander, Wisconsin) of the U.S. Forest Service.

2 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 parameters value must be “Dynamic Biomass Fuels”

2.2 Timestep

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

2.3 Species Fuel Coefficients

This parameter is a list of tree species with user-assigned fuel coefficients for determining relative dominance as a fuel type. If a species is not listed the default value is one (1).

2.4 Hardwood Maximum

The optional Hardwood Maximum value determines the maximum percent (%) hardwood acceptable for a site to be placed into a coniferous fuel group and must be an integer between 1 and 100. If this parameter is not present, then the default value of zero (0) is used.

2.5 Dead Fir Maximum Age

The DeadFirMaxAge value determines the duration of influence for the dead conifer index produced by the BDA Extension. After this amount of time has passed since the last BDA event for each site, the dead conifer index for that site will be reset to 0.

2.6 Fuel Type Table

This suite of parameters defines the desired fuel type classification outputs and must be preceded by the keyword FuelTypes. The input is a table with user-defined fuel types, a base fuel category for each fuel type, the characteristic species for each fuel type, and the cohort age range for the characteristic species in each fuel type (Table 1).

Table 1.

Parameter	Data Type	Units	Example
Fuel Type Index	int		1
BaseFuel	string		Deciduous
Age range	{int} to {int}	years	0 to 40
Species	string		pinustro

The Fuel Type Index is an integer value that connects the fuel type to fuel parameters in the Fire Extension. The index values provided here should match index values included in the FuelTypeTable in the fire extension input file. All index values in the fuel input file must be included in the fire input file.

The BaseFuel category defines which fuel types are considered Conifer, ConiferPlanation, Deciduous, Open, or Slash. These categories are used in calculations of conifer dominance and for fire spread and severity calculations in the Fire Extension. The base fuel category identified for each fuel type here should match the base fuel category defined for the same fuel type in the Fire Extension FuelTypeTable input.

If a species should contribute to the dominance value of a fuel type, list the species name in the Species column. If a species should be subtracted from a fuel type, list the species name preceded by a '-' (negative) sign.

This table contains entries for fuel types within the coniferous, deciduous and open fuel groups. Unforested sites will have a default value of zero (0), unless a default fuel type is specified for the ecoregion in the Fire Extension.

2.7 Ecoregion Table

Each fuel type can optionally be limited to one or more ecoregions. **The ecoregion listed must be the same as defined in the main scenario file.** If the ecoregion table is turned on, then ecoregions must be listed for every fuel type. **If a fuel type is not listed in the table, it cannot be selected.**

The optional table name is EcoregionTable. The first column is the Fuel Type Index, followed by a list of ecoregion names separated by white spaces. Each fuel type must be listed on a separate line.

2.8 Post Disturbance Fuel Information

This optional suite of parameters defines the conditions under which the fuel types are modified by other disturbances and must be preceded by the keyword **DisturbanceConversionTable**. The input is fuel type index, the maximum duration (age in years) of each disturbance fuel type, and the exact name of the harvest prescription used in the Base Harvest Extension or disturbance type and severity class that will create that particular fuel type (Table 3). The fuel type index should correspond to fuel type indices included in the Fire Extension input file. The keywords **FireSeverity** and **WindSeverity** have been designated to cause fire and wind disturbances to change fuel types. Each keyword should be followed immediately (no space) by the severity class (1-5) of that disturbance to be used (e.g., FireSeverity3, WindSeverity4).

Table 3.

Parameter	Data Type	Units	Example
Fuel Type	integer		13
Duration	integer	years	3
Prescription	string		JackPineClear
			WindSeverity4

2.9 Fuel Type Maps

The next parameter, MapFileNames, describes where the fuel type map is placed and its format. **This convention applies to all map names.** The first portion lists the directory where the maps should be placed relative to the location of the scenario text file (e.g., fire/). The parameter value "timestep" must be included and will be replaced with the output time step. Other characters can be inserted as desired. A meaningful file extension (e.g., .gis) should also be included.

Fuel types are mapped as their index + 1. Non-active sites are given a value of zero.

2.10 Percent Conifer Map Name

The next parameter, PctConiferMapName, describes where the percent conifer output maps are placed and their format. The first portion lists the directory where the maps should be placed relative to the location of the scenario text file (e.g., fire/). The parameter value "timestep" must be included and will be replaced with the output time step. Other characters can be inserted as desired. A meaningful file extension (e.g., .gis) should also be included.

2.11 Percent Dead Fir Map Name

The final parameter, PctDeadFirMapName, describes where the percent dead fir output maps are placed and their format. The first portion lists the directory where the maps should be placed relative to the location of the scenario text file (e.g., fire/). The parameter value "timestep" must be included and will be replaced with the output time step. Other characters can be inserted as desired. A meaningful file extension (e.g., .gis) should also be included.

3 Example File

```
LandisData  "Dynamic Biomass Fuels"

Timestep  10

>>            Fuel
>> Species    Coefficient
>> --------   -----------
   betupapy    0.90
   piceglau    0.95


>> Optional Percent Hardwood Value (%)
HardwoodMaximum    10

DeadFirMaxAge  15

FuelTypes
>> Fuel Type      BaseFuel    Age Range       Species
>> ---------      --------    ---------     ----------
   2              Conifer     0 to 400     piceglau abiebals
   3              Conifer     0 to 40      pinubank
   4              Conifer     41 to 100    pinubank
   5              Conifer     100 to 400   pinustro pinuresi –abiebals
   6              ConiferPlantation 10 to 100    pinustro pinuresi
   16             Open        0 to 10      pinustro pinuresi
   8              Deciduous   0 to 1000    betupapy

DisturbanceConversionTable
>> FuelType    Duration    Prescription (more than one allowed)
>> ----------   ------    --------------
13               5        JackPineClearCut
14               15       WhiteSpruceHarvest


MapFileNames    fire/FuelType-{timestep}.gis
PctConiferMapFileName fire/PctConifer-{timestep}.gis
PctDeadFirMapFileName fire/PctDeadFir-{timestep}.gis
```