LANDIS-II SCRAPPLE (v1.0) User Guide

Robert M. Scheller[1]
Alec Kretchun[2]

[1]North Carolina State University
[2]The Portland State University

Last Revised by Robert Scheller: March 30, 2018

Introduction

This document describes the Social-Climate Related Pyrogenic Processes and their Landscape Effects (SCRAPPLE) extension for the LANDIS-II model. For information about the model and its core concepts, see the *LANDIS-II Conceptual Model Description.* A description of this extension has not yet been published.

1.1. Fire Simulation

There are four primary algorithms: Ignition, Spread, Fire Intensity, and Fire Severity.

1.2. Major Versions

1.2.1. Version 1.0 (April 2018)

First release.

1.3. Minor Versions

1.4. References

Scheller, R.M., A.M. Kretchun, T. Hawbaker, and P. Henne. Social-Climate Related Pyrogenic Processes and their Landscape Effects (SCRAPPLE): A Landscape Model of Variable Social-ecological Fire Regimes. *In preparation.*

1.5. Acknowledgments

Funding for this extension was provided by USFS Southwest Region.

2. Parameter Input File

Most of 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 `"SCRAPPLE"`.

2.2. Timestep

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

2.3. AccidentalIgnitionsMap

This parameter specifies a raster map to represent where accidental ignition occur. The map units are double (allowing for fractions). Units are not specified; the data weights the location of accidental ignitions occurrence.

2.4. LightningIgnitionsMap

This parameter specifies a raster map to represent where lightning ignitions occur. The map units are double (allowing for fractions). Units are not specified; the data weights the location of lightning ignitions occurrence.

2.5. RxIgnitionsMap

This parameter specifies a raster map to represent where prescribed fire occur. The map units are double (allowing for fractions). Units are not specified; the data weights the location of prescribed fire occurrence.

2.6. AccidentalSuppressionMap

This parameter specifies a raster map to represent where and how accidental fires are suppressed. The map units are integers and should only include: 0, 1, 2, 3, indicating no suppression, light, moderate, and maximal suppression.

2.7. LightningSuppressionMap

This parameter specifies a raster map to represent where and how lightning fires are suppressed. The map units are integers and should only include: 0, 1, 2, 3, indicating no suppression, light, moderate, and maximal suppression.

2.8. RxSuppressionMap

This parameter specifies a raster map to represent where and how prescribed fires are suppressed. The map units are integers and should only include: 0, 1, 2, 3, indicating no suppression, light, moderate, and maximal suppression.

2.9. GroundSlopeFile

This parameter specifies a raster map to represent percent ground slope. The map should have integer values representing percent slope on the ground.

2.10. UphillSlopeAzimuthMap

This parameter specifies a raster map to represent the direction of uphill slope. Values in this map should be integers ranging from 0 to 360 degrees, specifying the direction upslope. Note: this is the opposite of the way aspect is commonly defined.

2.11. LightningIgnitionsB0

The B0 parameter from equation 1 (Scheller et al. in prep.). This value is empirically derived for lightning ignitions.

2.12. LightningIgnitionsB1

The B1 parameter from equation 1 (Scheller et al. in prep.). This value is empirically derived for lightning ignitions.

2.13. AccidentalIgnitionsB0

The B0 parameter from equation 1 (Scheller et al. in prep.). This value is empirically derived for accidental ignitions.

2.14. AccidentalIgnitionsB1

The B1 parameter from equation 1 (Scheller et al. in prep.). This value is empirically derived for accidental ignitions.

2.15. MaximumFineFuels

The amount of fine fuels (g m^{-2}) used to rescale the fine fuel parameter in equations 3 and 6 of Scheller et al. (in prep.). This parameter is typically estimated from 'typical' conditions not including prior large disturbance (e.g., fire or insect mortality) events. Fine fuels are estimated from surficial organic matter.

2.16. MaximumRxWindSpeed

The maximum wind speed under which prescribed fires will be put on the landscape.

2.17. MaximumRxFireWeatherIndex

The maximum Fire Weather Index under which prescribed fires will be put on the landscape.

2.18. MinimumRxFireWeatherIndex

The minimum Fire Weather Index under which prescribed fires will be put on the landscape. Typically prescribed fires will *not* be attempted if fuels are too moist.

2.19. NumberRxAnnualFires

The number of prescribed fires attempted per year.

2.20. FirstDayRxFires

The first Julian day in which a prescribed fire can begin. This is important if fall burning is preferred over spring burning.

2.21. MaximumSpreadAreaB0

The B0 parameter from equation 4 (Scheller et al. in prep.). This value is empirically derived from all fires in the landscape or region.

2.22. MaximumSpreadAreaB1

The B1 parameter from equation 4 (Scheller et al. in prep.). This value is empirically derived from all fires in the landscape or region.

2.23. MaximumSpreadAreaB2

The B2 parameter from equation 4 (Scheller et al. in prep.). This value is empirically derived from all fires in the landscape or region.

2.24. SpreadProbabilityB0

The B0 parameter from equation 6 (Scheller et al. in prep.). This value is empirically derived from all fires in the landscape or region.

2.25. SpreadProbabilityB1

The B1 parameter from equation 6 (Scheller et al. in prep.). This value is empirically derived from all fires in the landscape or region.

2.26. SpreadProbabilityB2

The B2 parameter from equation 6 (Scheller et al. in prep.). This value is empirically derived from all fires in the landscape or region.

2.27. SpreadProbabilityB3

The B3 parameter from equation 6 (Scheller et al. in prep.). This value is empirically derived from all fires in the landscape or region.

2.28. IntensityFactor:FineFuelPercent

The fraction (0.0 – 1.0) of fine fuel (see 2.15) that substantially increases the risk of a fire becoming either moderate or high severity.

2.29. IntensityFactor:LadderFuelMaxAge

Determines the maximum age at which a cohort is considered a ladder fuel. The biomass of all cohorts listed in `LadderFuelSpeciesList`, below, and younger than this age are summed and compared against `SeverityFactor:LadderFuelBiomass`, also below.

2.30. IntensityFactor:LadderFuelBiomass

The ladder fuel biomass (see 2.15) that substantially increases the risk of a fire becoming either moderate or high severity.

2.31. LadderFuelSpeciesList

A list of species codes for species that are considered ladder fuels.

2.32. SuppressionMaxWindSpeed

The wind speed (m^{s-1}) above which no resources would be deployed to suppress a fire.

2.33. DeadWoodTable

This table was designed to track snags generated by fire. There can be zero or more lines, each corresponding to a species. For each species, there's a minimum age at which a cohort generates snags due to fire. For example:

```
DeadWoodTable
PinuJeff    50
```

2.34. FireIntensityClass_1_DamageTable

For each damage table, a given age range for each species is associated with a probability of mortality, assuming that fire intensity = 1 (< 4" flame

length). There is no limit to the number of species or age ranges; the default value for an unlisted species or age-range is 0.0.

2.34.1. Species Name

2.34.2. Minimum Age

2.34.3. Maximum Age

2.34.4. Probability of Mortality

Range of 0.0 – 1.0. Compared against a randomly generated uniform value to determine mortality. All mortality is total.

2.35. FireIntensityClass_2_DamageTable

Same as above; applied to fire intensity = 2 (4-8” flame length).

2.36. FireIntensityClass_3_DamageTable

Same as above; applied to fire intensity = 3 (> 8” flame length).

3. Output Files

The extension outputs were designed to be able to correctly parameterize and analyze fire behavior in the simulation. The Fire ignition table is designed to capture the relationship between attempted FWI and number of fire ignitions for each type, for each day and year. The Fire event table is designed to record the fire characteristics of each individual fire event. The Fire landscape table is designed to summarize fire characteristics at the landscape scale.

3.1. Fire Severity Maps

The map of fire severity is labeled 0 for non-active sites, 1 for active and not disturbed sites, and [fire severity + 1] for all disturbed sites. A map is produced for each fire time step.

3.2. Fire Ignition Maps

There are three ignition types with values: 2=Accidental; Lightning=3; Rx=4.

3.3. Fire Ignition Log

Year: Simulation year step of the ignition
Day: Julian day of the ignition
FWI: Fire Weather Index
IgnitionType: Lightning, Human Accidental, or Prescribed fire

3.4. Fire Event Log

The event log is a text file that contains information about every event over the course of the scenario: year, initiation cell coordinates, initiation ecoregion value, initiation fuel type, initiation percent conifer, selected size/duration, actual duration, fire season, wind speed, wind direction, FFMC, BUI, % grass curing, number of damaged sites, number of cohorts killed total, mean fire severity across all sites, number of cells burned by ecoregion, and total fire size (number of cells). The information is stored as comma-separated values (CSV).

3.5. Fire Time Step Log

The fire time step log is a text file that contains summary information about all the events that occurred during each fire time step: year, total number of cells burned, total number of cells burned by ecoregion, and total number of events,. The information is stored as comma-separated values (CSV).

Year: Simulation year step of the ignition
Number of fires (by fire type): self explanatory
Total Burned Sites (by fire type): self explanatory
Biomass Consumed (by fire type): Amount of biomass (g C m-2)

consumed by fire
Number of cells Low Intensity: Number burned sites across the simulation that is < 4’

Number of cells Moderate Intensity: Number burned sites across the simulation that is 4-8’
Number of cells High Intensity: Number burned sites across the simulation that is > 8’

4. Sample Input File

```
LandisData  "SCRAPPLE"

>> Note:  All inputs are provided as examples only.  They are not intended to serve as
            default values.
Timestep                            1

AccidentalIgnitionsMap     ./Accidental_Ignition_Map.img
LightningIgnitionsMap  ./Lightning_Ignition_Map.img
RxIgnitionsMap  ./Lightning_Ignition_Map.img

AccidentalSuppressionMap      ./test_suppress.img
LightningSuppressionMap               ./test_suppress.img
RxSuppressionMap              ./test_suppress.img

GroundSlopeMap GroundSlope.gis
UphillSlopeAzimuthMap  UphillSlope.gis

LightningIgnitionsB0  -3.0
LightningIgnitionsB1  0.005
AccidentalIgnitionsB0 -3.0
AccidentalIgnitionsB1 0.005
MaximumFineFuels 60.0  << Use the NECN primary log file to determine typical values
MaximumRxWindSpeed 10.0
MaximumRxFireWeatherIndex 30.0
MinimumRxFireWeatherIndex 5.0
NumberRxAnnualFires 5

MaximumSpreadAreaB0    3.1
MaximumSpreadAreaB1    0.0
MaximumSpreadAreaB2    0.0

SpreadProbabilityB0 -1.0
SpreadProbabilityB1 0.085  <<FWI
SpreadProbabilityB2 -0.005  << fine fuels
SpreadProbabilityB3 -0.33  << wind speed

SeverityFactor:FineFuelPercent  50.0
SeverityFactor:LadderFuelMaxAge 50
SeverityFactor:LadderFuelBiomass -1.0
LadderFuelSpeciesList
```

```
acersacc pinustro



SuppressionEffectiveness:LightningLow        5
SuppressionEffectiveness:LightningMedium     50
SuppressionEffectiveness:LightningHigh               75
SuppressionEffectiveness:RxLow                       5
SuppressionEffectiveness:RxMedium            50
SuppressionEffectiveness:RxHigh                      75
SuppressionEffectiveness:AccidentalLow               5
SuppressionEffectiveness:AccidentalMedium    50
SuppressionEffectiveness:AccidentalHigh              75



FireIntensityClass_1_DamageTable
>> Format = species [maxAge Pmortality] ... [repeating]  Any missing data is 0.0
acersacc 0 50  0.9
acersacc 51 100 0.5

FireIntensityClass_2_DamageTable
>> Format = species [maxAge Pmortality] ... [repeating]  Any missing data is 0.0
acersacc 0 50  0.9
acersacc 51 100 0.5

FireIntensityClass_3_DamageTable
>> Format = species [maxAge Pmortality] ... [repeating]  Any missing data is 0.0
acersacc 0 50  0.9
acersacc 51 100 0.5
```