LANDIS-II SCRAPPLE (v1.0) User Guide

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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 map data weights the location of accidental ignitions occurrence whereby the list of values are sorted with higher values more likely near the top; ignitions are sequentially drawn from this weighted, sorted list.

User Tip: If empirical ignition data exist, these can be used to create a continuous surface of probability of ignition per year. If no such data exist, the map can have a single value and will therefore random locations will be selected.

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 map data weights the location of accidental ignitions occurrence whereby the list of values are sorted with higher values more likely near the top; ignitions are sequentially drawn from this weighted, sorted list.

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 map data weights the location of accidental ignitions occurrence whereby the list of values are sorted with higher values more likely near the top; ignitions are sequentially drawn from this weighted, sorted list.

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 can be 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 ignited 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.

Note: Though empirically derived, this parameter can be used to match fire regime calibration targets.

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.

Note: Though empirically derived, this parameter can be used to match fire regime calibration targets.

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 first of three fuels factors that help determine fire intensity. 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

The second of three fuels factors that help determine fire intensity. The maximum age at which a cohort is considered a ladder fuel. The biomass of all cohorts ≥`LadderFuelMaxAge` listed in `LadderFuelSpeciesList` are summed and compared against `SeverityFactor:LadderFuelBiomass`, also below.

2.30. IntensityFactor:LadderFuelBiomass

The third of three fuels factors that help determine fire intensity. 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. This parameter is intended to capture weather conditions under which fire response is prohibitively dangerous.

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. Day of Fire Map

The map of 'fire days' tracks on which day of the year a cell burned. Map values equal Julian day of time step.

3.2. Fire Intensity Maps

The map of fire intensity reports at which intensity (1-3) a cell burned. Map values: 0 = Unburned site, 1-3 = Fire intensity 1-3

3.3. Fire Ignition Type Maps

There are three ignition types with values: 0 = Unburned or non-active site, 1 = Accidental; 2 = Lightning; 3 = Rx.

3.4. 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

3.5. Fire Event Log

The event log is a text file that contains information about every event over the course of the scenario: year, ignition row number, ignition column number, initial Fire Weather Index, initial Julian day, ignition type, number of days a fire burned, total sites burned, number of cohorts killed, mean wind speed, mean effective wind speed, mean wind azimuth direction, mean suppression effectiveness level, mean Fire Weather Index, mean spread probability, mean fire severity, total biomass killed, number of cells in fire intensity class 1, number of cells in fire intensity class 2, number of cells in fire intensity class 3. The information is stored as comma-separated values (CSV).

3.6. Fire Summary 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

>>Prescribed fire burn window parameters
MaximumRxWindSpeed 10.0
MaximumRxFireWeatherIndex 30.0
MinimumRxFireWeatherIndex 5.0
NumberRxAnnualFires 5
FirstDayRxFires 25

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

SuppressionMaxWindSpeed 40
SuppressionTable
>>Type          FWI1    FWI2    Lo      Md      High-Effectiveness
Accidental      20      40      5       5       5
Lightning       20      40      5       5       5
Rx              20      40      5       5       5

DeadWoodTable
acersacc  20
pinustro  20

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
```