

# LANDIS-II Local Habitat Suitability Output Extension (v1.0) User Guide

Donald J. Brown<sup>1\*</sup>

Brian R. Miranda<sup>2</sup>

<sup>1</sup>Wisconsin Cooperative Wildlife Research Unit, Department of Forest and Wildlife Ecology,  
University of Wisconsin, Madison, WI

<sup>2</sup>USDA Forest Service, Northern Research Station, Rhinelander, WI

Last Revised by Brian Miranda: September 8, 2017

Previous revision: August 9, 2017

\* Current affiliation: West Virginia University, School of Natural Resources, Morgantown,  
WV & USDA Forest Service, Northern Research Station, Parsons, WV

**INTRODUCTION .....2**

1.1. Reclassification.....2

    1.1.1. Age Reclassification.....3

    1.1.2. Biomass Reclassification .....3

1.2. Disturbance Weighting .....3

    1.2.1. Fire Severity Weighting .....4

    1.2.2. Harvest Prescription Weighting .....4

1.3. Post-Processing.....5

1.4. Major Versions .....5

    1.4.1. Version 1.0.....5

1.5. Minor Versions.....5

1.6. References .....5

1.7. Acknowledgments .....6

**2. PARAMETER INPUT FILES .....7**

2.1. Main Parameter File .....7

    2.1.1. LandisData .....7

    2.1.2. Timestep.....7

    2.1.3. Output Timestep.....7

    2.1.4. Map Names .....7

    2.1.5. Suitability File Names.....7

2.2. Habitat Suitability Input Files.....8

    2.2.1. LandisData .....8

    2.2.2. HabitatName.....8

    2.2.3. SuitabilityType .....8

        2.2.3.1. AgeClass\_ForestType .....8

            2.2.3.1.1. ReclassCoefficients.....9

                2.2.3.1.1.1. Species Column .....9

                2.2.3.1.1.2. Reclass Coefficient .....9

            2.2.3.1.2. ForestTypeTable.....9

            2.2.3.1.3. SuitabilityTable .....9

        2.2.3.2. AgeClass\_TimeSinceDisturbance .....10

            2.2.3.2.1. DisturbanceTable - Fire.....10

            2.2.3.2.2. DisturbanceTable - Harvest .....11

            2.2.3.2.3. SuitabilityTable .....12

        2.2.3.3. DisturbedForestType\_TimeSinceDisturbance .....12

            2.2.3.3.1. ReclassCoefficients.....13

                2.2.3.3.1.1. Species Column .....13

                2.2.3.3.1.2. Reclass Coefficient .....13

            2.2.3.3.2. ForestTypeTable.....13

            2.2.3.3.3. DisturbanceTable - Fire.....13

            2.2.3.3.4. DisturbanceTable - Harvest .....14

            2.2.3.3.5. SuitabilityTable .....15

**3. OUTPUT FILES .....16**

**4. SAMPLE INPUT FILES .....17**

4.1. Main Parameter File .....17

4.2. Habitat Suitability Input Files.....17

    4.2.1. AgeClass\_ForestType .....17

    4.2.2. AgeClass\_TimeSinceDisturbance .....18

    4.2.3. DisturbedForestType\_TimeSinceDisturbance .....18

## Introduction

This document describes the **Local Habitat Suitability** extension for the LANDIS-II model. For information about the model and its core concepts, see the *LANDIS-II Conceptual Model Description*. Users not familiar with LANDIS-II should read the *LANDIS-II Model User Guide* prior to reading this document. Further, this extension optionally utilizes output from other LANDIS-II extensions, and users should be familiar with the case-specific extensions generating input for this extension. We also highly recommend that users new to the LANDIS modeling environment read Mladenoff (2004), Scheller et al. (2007), and Sturtevant et al. (2009). For examples of studies that have utilized LANDIS or LANDIS-II output in wildlife research see Akçakaya et al. (2004), Akçakaya et al. (2005), Scheller et al. (2011), Shifley et al. (2006), Spencer et al. (2011), and Zollner et al. (2005).

The **Local Habitat Suitability** extension is designed to facilitate habitat suitability analyses using LANDIS-II model output. Prior to this extension, individuals interested in using LANDIS-II output to investigate habitat suitability were required to perform all habitat suitability classification actions outside of the LANDIS-II model environment, typically importing the model output into a Geographic Information System (GIS) for further analysis. This extension improves the value of LANDIS-II for habitat suitability analyses by performing cell-level habitat suitability classifications within the LANDIS-II model.

Advantages of using this extension compared to performing all habitat suitability modeling outside of the LANDIS-II model environment include: 1) substantial reduction in post-processing effort; 2) ability to quickly visualize and compare habitat suitability output among scenarios and classification schemes, including compatibility with the LandViz Visualization Tool (<http://www.landis-ii.org/tools/viz-tool>); and 3) ability to track habitat characteristics that are not obtainable from LANDIS-II output maps alone. For example, time since fire in conjunction with stand age and/or species composition prior to burning can be a useful proxy for habitat suitability. Because both stand age and species composition values can change as a result of fire, it is necessary to know the habitat states prior to fires in order to properly classify post-fire habitat suitability. This information can be easily tracked internally but can be cumbersome to extract through GIS post-processing.

### 1.1. Reclassification

This extension uses a reclassification method to categorize sites into mutually exclusive forest types based on the composition of cohorts. The methods of reclassification used in this extension have been copied directly from the *Age Reclassification Output* (<http://www.landis-ii.org/extensions/age-reclassification-output>) and *Output Biomass*

*Reclassification* (<http://www.landis-ii.org/extensions/biomass-reclassification-output>) extensions.

### 1.1.1. Age Reclassification

This output extension uses cohort information at each site to classify every active site into a forest type defined by the user. A fuzzy algorithm is used whereby a dominance value is calculated for each species:

$$D_{Species} = \text{MaximumAge}_{Species} / \text{Longevity}_{Species} \times \text{ReclassCoefficient}_{Species}$$

Maximum age is the oldest cohort for that species for that site. The species reclassification (reclass) coefficient is a user-defined input value ( $0.0 \leq RC \leq 1.0$ ).

Each forest type has an associated group of species. The species dominance values are summed for each forest type to which they are assigned. Some species may have a negative dominance for a given forest type, as determined by the user. A site is assigned to (given the value of) the forest type with the highest total dominance value.

**Note: If the reclassification calculates equal values for more than one forest type (a tie), then the forest type listed first among equals will be assigned to that cell.**

See the *Age Reclassification Output* extension user guide for additional information.

### 1.1.2. Biomass Reclassification

This output extension uses cohort information at each site to classify every active site into a single forest type defined by the user. A dominance value is calculated for each species, equal to the total biomass (B) (Mg/ha) for the species on the site.

Each forest type has an associated group of species. On each site, the species dominance values are summed for each forest type to which they are assigned. When determined by the user, species values may be subtracted for a given forest type, in cases where the absence of the species is indicative of the forest type. A site is assigned to (given the value of) the forest type with the highest total dominance value.

See the *Biomass Reclassification Output Extension User Guide* for additional information.

## 1.2. Disturbance Weighting

This extension allows the user to model habitat suitability based on time since disturbance. For this initial release we incorporated two disturbance types, fire and harvest. Because disturbances can vary with respect to

magnitude of impacts on forest communities, the user can account for those differences using disturbance weighting.

### 1.2.1. Fire Severity Weighting

Severity of fire often affects wildlife habitat suitability (e.g., Smucker et al. 2005, Hutto 2008, Fontaine and Kennedy 2012), and this extension provides an option to use fire history in combination with forest type or stand age to estimate habitat suitability values. Fire severity classes range from 1 (equivalent to a low intensity ground fire) to 5 (a stand replacing fire) in the Base Fire and Dynamic Fire System extensions. When using time since fire as a component of habitat suitability, the user must weight each fire severity class for its potential contribution to habitat suitability. Weights are decimal values ranging from 0 to 1. If the user does not wish to weight fire severity, a value of 1 should be entered for all fire severity classes. Alternately, if some fire severity classes create suitable habitat and others do not, a value of 0 should be entered for the fire severity classes that create unsuitable habitat. Values in between 0 and 1 can be used to represent variable suitability for different severity classes and affect the classification table by acting as a multiplier. For instance, if a time since fire/age class combination is given a habitat suitability value of 2 in the classification table, and the fire severity class affecting a cell with that combination is given a weighting value of 0.5 (i.e., between unsuitable and optimal suitability), the resulting habitat suitability value for the cell would be 1.0.

### 1.2.2. Harvest Prescription Weighting

Harvest prescriptions (i.e., amount, timing, and arrangement of harvesting) often affects wildlife habitat suitability (e.g., Marzluff et al. 2002, Zollner et al. 2005, Shifley et al. 2006), and this extension provides an option to use harvest history in combination with forest type or stand age to estimate habitat suitability values. Harvest prescriptions are user defined in the Base Harvest and Biomass Harvest extensions. When using time since harvest as a component of habitat suitability, the user must weight each harvest prescription for its potential contribution to habitat suitability. Weights are decimal values ranging from 0 to 1. If the user does not wish to weight harvest prescription, a value of 1 should be entered for all harvest prescription classes. Alternately, if some harvest prescription classes create suitable habitat and others do not, a value of 0 should be entered for the harvest prescription classes that create unsuitable habitat. Values in between 0 and 1 can be used to represent variable suitability for different prescriptions and affect the classification table by acting as a multiplier. For instance, if a harvest prescription/age class combination is given a habitat suitability value of 2 in the classification table, and the harvest prescription affecting a cell with that combination is given a value of 0.5 (i.e., between unsuitable and optimal suitability), the habitat suitability value for the cell would be 1.

### 1.3. Post-Processing

Although this extension is designed to assist with wildlife habitat suitability analyses within the LANDIS-II model environment, for some studies additional post-processing may be necessary. Some examples of common post-processing projects include:

- 1) If multiple habitat suitability files are created, those will need to be imported into a GIS and the cells reclassified based on user-defined rules.
- 2) Depending on the cell size used in the simulations and the species of interest, it may also be useful to reclassify suitable habitat based on spatial metrics (e.g., patch size and fragmentation metrics).
- 3) In some cases important variables not accounted for in the LANDIS-II vegetation and fire simulations (e.g., movement barriers) will also need to be integrated into the habitat suitability analyses during the post-processing stage.
- 4) Because LANDIS-II simulations are usually conducted using an area larger than the study area of interest (to mitigate the influence of simulation space boundaries on cells of interest), the study area of interest might need to be clipped from the output maps prior to further statistical analyses.

### 1.4. Major Versions

#### 1.4.1. Version 1.0

Version 1.0 (and later) is the first official release of this extension, and is compatible with LANDIS-II v6.2.

### 1.5. Minor Versions

### 1.6. References

- Akçakaya, H.R., J. Franklin, A.D. Syphard, and J.R. Stephenson. 2005. Viability of Bell's sage sparrow (*Amphispiza belli* ssp. *belli*): altered fire regimes. *Ecological Applications* 15:521-531.
- Akçakaya, H.R., V.C. Radeloff, D.J. Mladenoff, and H.S. He. 2004. Integrating landscape and metapopulation modeling approaches: viability of sharp-tailed grouse in a dynamic landscape. *Conservation Biology* 18:526-537.
- Fontaine, J.B., and P.L. Kennedy. 2012. Meta-analysis of avian and small-mammal response to fire severity and fire surrogate treatments in U.S. fire-prone environments. *Ecological Applications* 22:1547-1561.
- Hutto, R.L. 2008. The ecological importance of severe wildfires: some like it hot. *Ecological Applications* 18:1827-1834.

- Marzluff, J.M., Millspaugh, J.J., Ceder, K.R., Oliver, C.D., Withey, J., McCarter, J.B., Mason, C.L., Comnick, J. 2002. Modeling changes in wildlife habitat and timber revenues in response to forest management. *Forest Science* 48:191-202.
- Mladenoff, D.J. 2004. LANDIS and forest landscape models. *Ecological Modelling* 180:7-19.
- Scheller, R.M., J.B. Domingo, B.R. Sturtevant, J.S. Williams, A. Rudy, E.J. Gustafson, and D.J. Mladenoff. 2007. Design, development, and application of LANDIS-II, a spatial landscape simulation model with flexible temporal and spatial resolution. *Ecological Modelling* 201:409-419.
- Scheller, R.M., W.D. Spencer, H. Rustigian-Romsos, A.D. Syphard, B.C. Ward, and J.R. Strittholt. 2011. Using stochastic simulation to evaluate competing risks of wildfires and fuels management on an isolated forest carnivore. *Landscape Ecology* 26:1491-1504.
- Shifley, S.R., Thompson, F.R., Dijak, W.D., Larson, M.A., Millspaugh, J.J. 2006. Simulated effects of forest management alternatives on landscape structure and habitat suitability in the Midwestern United States. *Forest Ecology and Management* 229:361-377.
- Smucker, K.M., R.L. Hutto, and B.M. Steele. 2005. Changes in bird abundance after wildfire: importance of fire severity and time since fire. *Ecological Applications* 15:1535-1549.
- Spencer, W., H. Rustigian-Romsos, J. Strittholt, R. Scheller, W. Zielinski, and R. Truex. 2011. Using occupancy and population models to assess habitat conservation opportunities for an isolated carnivore population. *Biological Conservation* 144:788-803.
- Sturtevant, B.R., R.M. Scheller, B.R. Miranda, D. Shinneman, and A. Syphard. 2009. Simulating dynamic and mixed-severity fire regimes: A process-based fire extension for LANDIS-II. *Environmental Management* 220:3380-3393.
- Zollner, P.A., E.J. Gustafson, H.S. He, V.C. Radeloff, and D.J. Mladenoff. 2005. Modeling the influence of dynamic zoning of forest harvesting on ecological succession in a northern hardwoods landscape. *Ecological Modelling* 35:410-425.

## 1.7. Acknowledgments

Development of this LANDIS-II extension has been supported in part by the National Fire Plan and the U.S. Geological Survey Science Support Partnership. We thank Brian Sturtevant and Deahn Donner for an insightful conversation that sparked the development of this extension. We also thank Chris Ribic and Brian Sturtevant for reviewing earlier drafts of this User Guide.

## 2. Parameter Input Files

The input parameters for this extension are specified in two or more input files. The main parameter file includes a list of one or more habitat input files. The input text files must comply with the general format requirements described in section 3.1 *Text Input Files* in the *LANDIS-II Model User Guide*.

### 2.1. Main Parameter File

#### 2.1.1. LandisData

This parameter's value must be "Local Habitat Suitability".

```
LandisData "Local Habitat Suitability"
```

#### 2.1.2. Timestep

This parameter is the extension's timestep. This parameter designates how frequently the extension runs and updates internal information. Value: integer > 0. Units: years.

```
Timestep 1
```

**Note:** In most cases the timestep should be equal to the shortest timestep used in other relevant extensions (e.g., succession, fire) to allow accurate calculations of variables such as stand age and time since fire.

#### 2.1.3. Output Timestep

The third parameter (OutputTimestep) is the frequency of output generated from this extension in years. The output timestep can be equal to or greater than the extension timestep. Value: integer > 0. Units: years.

```
OutputTimestep 10
```

#### 2.1.4. Map Names

The next parameter, MapFileNames, describes where output maps are placed and their format. The first portion lists the directory where the maps should be placed, relative the location of the scenario text file (e.g., output/habitat). The second portion includes two variables for creating file names. {HabitatName} will be replaced with the habitat map name provided in the Suitability Files. {timestep} will be replaced with the output time step. Other characters can be inserted as desired. A meaningful file extension (e.g., .img) should also be included. For example:

```
MapFileNames output/habitat/{HabitatName}-{timestep}.img
```

#### 2.1.5. Suitability File Names

This section of the input file provides the file names for habitat suitability tables (see section 2.2) to be included. The list of files must be preceded



by the keyword `SuitabilityFiles`, and should include one file for each habitat suitability output desired.

```
SuitabilityFiles  ageclass_foresttype_example.txt
                  ageclass_tsd_example.txt
                  foresttype_tsd_example.txt
```

## 2.2. Habitat Suitability Input Files

Each habitat suitability file must contain a suite of parameters defined below. The suitability file can take one of three distinct forms depending on the `SuitabilityType` that is used. Each file will contain a `SuitabilityTable`, which will be preceded by a `ForestTypeTable`, and a `DisturbanceTable`. The structure of the `SuitabilityTable` will also vary depending on the `SuitabilityType`.

### 2.2.1. LandisData

This parameter's value must be "HabitatSuitabilityFile".

```
LandisData  HabitatSuitabilityFile
```

### 2.2.2. HabitatName

This parameter's value will define the name of the output maps (see section 2.1.4).

```
HabitatName  Species1
```

### 2.2.3. SuitabilityType

Habitat suitability tables can take one of 3 distinct forms depending on the relevant habitat attributes for the species. This parameter uses a keyword to specify which form the remainder of the file will take. Options for this parameter are: `AgeClass_ForestType`, `AgeClass_TimeSinceDisturbance`, and `DisturbedForestType_TimeSinceDisturbance`. The sections below describe the remaining input parameters required for each form.

```
SuitabilityType  AgeClass_ForestType
```

#### 2.2.3.1. AgeClass\_ForestType

Using 'AgeClass\_ForestType' for the `SuitabilityType` utilizes a reclassification scheme to identify a dominant forest type, a dominant age class within that forest type, and a matrix of forest types and age classes to determine suitability values. The keywords 'ReclassCoefficients', 'ForestTypeTable' and 'SuitabilityTable' identify the start of each input type.

### 2.2.3.1.1. ReclassCoefficients

This table contains the reclass coefficients for various species. Each row has the coefficient for one species.

#### 2.2.3.1.1.1. Species Column

This column must be the name of a species defined in the species input file (see chapter 5 in the LANDIS-II Model User Guide). The names can be in any order. Not all the species have to be present; if a species is not present, its reclass coefficient is the default value of zero (0).

#### 2.2.3.1.1.2. Reclass Coefficient

This parameter is the reclass coefficient for the species. Value:  $0 \leq \text{number} \leq 1$ .

### 2.2.3.1.2. ForestTypeTable

The ForestTypeTable defines which species contribute to the dominance of each user-defined forest type. The reclassification follows the rules of either Age Reclassification Output or Biomass Reclassification Output, depending on which form of succession is being used (see section 1.1 for reclassification details). Each site is assigned to one forest type. If a site has no cohorts present for any species listed, it is not assigned to any forest type (0 value). Not all species need to be included and a species may be listed in more than one forest type. If a species' name is preceded by a minus sign ('-') then it is subtracted from the forest type's dominance value (there must be no whitespace between the minus sign and the species name).

ForestTypeTable

```
>> Forest Type      Species
>> -----
Pine                pinubank pinuresi pinustro
MapleHdwd           acersacc betualle abiebals fraxamer -pinubank
SpruceFir           piceglau picemari abiebals
Other               poputrem betupapy
```

### 2.2.3.1.3. SuitabilityTable

The SuitabilityTable defines the suitability value for each forest type across multiple age ranges. The first line provides the maximum age in years for each age class. There must be at least one age class provided, and there is no limit on how many age classes can be used, although maximum ages must be integer values.

The age classes define the age ranges within which the dominant age is evaluated. The dominant age is the age class that contains the most cohorts (Age-only) or most biomass (Biomass) among the species identified as contributing to the dominant forest type. For example, if the dominant forest type is 'Pine', then only cohorts of the species listed in the ForestTypeTable in the 'Pine' forest type are considered when determining dominant age. The number of cohorts, or cohort biomass, is summed within each age class and the age class with the highest value is considered the dominant age class.

The remaining lines in the table define the suitability values for each forest type and age class combination by listing the forest type (which must match a forest type in the ForestTypeTable above) and a suitability value for each age class. The number of suitability values must match the number of age classes defined by the first line of this table. Forest types in the ForestTypeTable that are not listed in the SuitabilityTable are assumed to have a value of 0 for all age classes. Suitability values in the table must be integer values but have no other restrictions.

```
SuitabilityTable
<< ForestType      Maximum Age Values
<< -----
                        10    30    999
<<
<< Suitability Values
<< -----
Pine                0     1     2
MapleHwdw          0     0     1
SpruceFir           0     0     1
Other               0     0     0
```

### 2.2.3.2. AgeClass\_TimeSinceDisturbance

Using 'AgeClass\_TimeSinceDisturbance' for the SuitabilityType utilizes a reclassification scheme to identify the dominant age class at the time of the last disturbance, and a matrix of age classes and times since disturbance to determine suitability values. The keywords 'SuitabilityTable' and 'DisturbanceTable' identify the start of each input type.

#### 2.2.3.2.1. DisturbanceTable - Fire

The DisturbanceTable for Fire defines the fire severity classes that are relevant to be tracked for purposes of habitat suitability. The keyword 'Fire' must follow 'DisturbanceTable' to designate that the following

table reflects fire severity classes. In some cases only severe (> 3) fires are of interest, while other times low severity or all severities will be relevant. The SuitabilityWeight for each severity class can be any value between 0 and 1, which determines the relative value of that fire severity for habitat suitability. For instance, if a time since fire/age class combination is given a habitat suitability value of 2 in the classification table, and the fire severity class affecting a cell with that combination is given a value of 0.5, the habitat suitability value for the cell would be 1.

```

DisturbanceTable      Fire
>>  Fire Severity Class      SuitabilityWeight
>>  -----
      0                        0
      1                        0
      2                        0
      3                        0.5
      4                        1
      5                        1

```

#### 2.2.3.2.2. DisturbanceTable - Harvest

The DisturbanceTable for Harvest defines the harvest prescription classes that are relevant to be tracked for purposes of habitat suitability. The keyword 'Harvest' must follow 'DisturbanceTable' to designate that the following table reflects harvest prescriptions. In some cases only certain classes will be relevant (e.g., clearcuts). The SuitabilityWeight for each prescription class can be any value between 0 and 1, which determines the relative value of that prescription for habitat suitability. For instance, if a prescription/age class combination is given a habitat suitability value of 2 in the classification table, and the harvest prescription class affecting a cell with that combination is given a value of 0.5, the habitat suitability value for the cell would be 1.

```

DisturbanceTable      Harvest
>>  Harvest Prescription Class      SuitabilityWeight
>>  -----
      RandomClearcutCut              0
      MaxAgeClearcut                 0.5
      SelectionCut                    1

```

### 2.2.3.2.3. SuitabilityTable

The SuitabilityTable defines the suitability value for each age class across multiple times since disturbance. The first line provides the maximum age in years for each age class. There must be at least one age class provided, and there is no limit on how many age classes can be used, although maximum ages must be integer values. The dominant age is the age class that contains the most cohorts (Age-only) or most biomass (Biomass) among all species. Unlike the dominant age defined above for ‘AgeClass\_ForestType’ (see section 2.2.3.1.3), here all species contribute to the dominant age class calculation. The number of cohorts, or cohort biomass, is summed within each age class and the age class with the highest value is considered the dominant age class.

The remaining lines in the table define the suitability values for each time since disturbance (TSD) and age class combination by listing the time since disturbance and a suitability value for each age class. Time since disturbance class values represent the maximum TSD for each TSD class. Time since disturbance is only tracked for disturbed cells where the disturbance equates to a >0 value in the FireSeverityTable or HarvestPrescriptionTable. There must be at least one TSD class provided, and there is no limit on how many TSD classes can be used, although classes must be integer values. The number of suitability values must match the number of age classes defined by the first line of this table. Times since disturbance that exceed the highest value listed in the SuitabilityTable are assumed to have a value of 0 for all age classes. Suitability values in the table must be integer values but have no other restrictions. The selected suitability value from the SuitabilityTable is multiplied by the SuitabilityWeight of the disturbance that initialized the time since disturbance.

```
SuitabilityTable
<< MaxTimeSinceDisturbance      Maximum Age Values
<< -----
<<                               10    30    999
<<                               -----
<<                               Suitability Values
<<                               -----
    5                             1     2     3
    10                            0     1     2
    9999                           0     0     1
```

### 2.2.3.3. DisturbedForestType\_TimeSinceDisturbance

Using ‘DisturbedForestType\_TimeSinceDisturbance’ for the SuitabilityType utilizes a reclassification scheme to identify the dominant forest type **at the time of the last disturbance**, and a matrix of disturbed forest types and times since disturbance to determine suitability values.

The keywords ‘ReclassCoefficients’, ‘ForestTypeTable’, ‘SuitabilityTable’, and ‘DisturbanceTable’ identify the start of each input type.

### 2.2.3.3.1. ReclassCoefficients

This table contains the reclass coefficients for various species. Each row has the coefficient for one species.

#### 2.2.3.3.1.1. Species Column

This column must be the name of a species defined in the species input file (see chapter 5 in the LANDIS-II Model User Guide). The names can be in any order. Not all the species have to be present; if a species is not present, its reclass coefficient is the default value of zero (0).

#### 2.2.3.3.1.2. Reclass Coefficient

This parameter is the reclass coefficient for the species. Value:  $0 \leq \text{number} \leq 1$ .

### 2.2.3.3.2. ForestTypeTable

The ForestTypeTable defines which species contribute to the dominance of each user-defined forest type. The reclassification follows the rules of either Age Reclassification Output or Biomass Reclassification Output, depending on which form of succession is being used (see section 1.1 for reclassification details). Each site is assigned to one forest type. If a site has no cohorts present for any species listed, it is not assigned to any forest type (0 value). Not all species need to be included and a species may be listed in more than one forest type. If a species’ name is preceded by a minus sign (‘-’) then it is subtracted from the forest type’s dominance value (there must be no whitespace between the minus sign and the species name).

ForestTypeTable

```
>> Forest Type      Species
>> -----
Pine                pinubank pinuresi pinustro
MapleHdwd           acersacc betualle abiebals fraxamer -pinubank
SpruceFir           piceglau picemari abiebals
Other               poputrem betupapy
```

### 2.2.3.3.3. DisturbanceTable - Fire

The DisturbanceTable for Fire defines the fire severity classes that are relevant to be tracked for purposes of habitat suitability. The keyword ‘Fire’ must follow ‘DisturbanceTable’ to designate that the following

table reflects fire severity classes. In some cases only severe (> 3) fires are of interest, while other times low severity or all severities will be relevant. The SuitabilityWeight for each severity class can be any value between 0 and 1, which determines the relative value of that fire severity for habitat suitability. For instance, if a time since fire/forest type combination is given a habitat suitability value of 2 in the classification table, and the fire severity class affecting a cell with that combination is given a value of 0.5, the habitat suitability value for the cell would be 1.

```

DisturbanceTable      Fire
>>  Fire Severity Class      SuitabilityWeight
>>  -----
      0                        0
      1                        0
      2                        0
      3                        0.5
      4                        1
      5                        1

```

#### 2.2.3.3.4. DisturbanceTable - Harvest

The DisturbanceTable for Harvest defines the harvest prescription classes that are relevant to be tracked for purposes of habitat suitability. The keyword 'Harvest' must follow 'DisturbanceTable' to designate that the following table reflects harvest prescriptions. In some cases only certain classes will be relevant (e.g., clearcuts). The SuitabilityWeight for each prescription class can be any value between 0 and 1, which determines the relative value of that prescription for habitat suitability. For instance, if a forest type/time since harvest combination is given a habitat suitability value of 2 in the classification table, and the harvest prescription class affecting a cell with that combination is given a value of 0.5, the habitat suitability value for the cell would be 1.

```

DisturbanceTable      Harvest
>>  Harvest Prescription Class      SuitabilityWeight
>>  -----
      RandomClearcutCut              0
      MaxAgeClearcut                 0.5
      SelectionCut                    1

```

### 2.2.3.3.5. SuitabilityTable

The SuitabilityTable defines the suitability value for each forest type across multiple times since disturbance. The first line provides the time since disturbance (TSD) class values, which represent the maximum TSD for each TSD class. Time since disturbance is only tracked for disturbed cells where the disturbance equates to a >0 value in the DisturbanceTable. There must be at least one TSD class provided, and there is no limit on how many TSD classes can be used, although classes must be integer values.

The remaining lines in the table define the suitability values for each TSD and forest type combination by listing the TSD and a suitability value for each forest type (i.e., the forest type that was disturbed). The number of suitability values in each row must match the number of TSD classes. Times since disturbance that exceed the highest value listed in the SuitabilityTable are assumed to have a value of 0 for all forest types. Suitability values in the table must be integer values but have no other restrictions. The selected suitability value from the SuitabilityTable is multiplied by the SuitabilityWeight of the disturbance that initialized the time since disturbance.

```
SuitabilityTable
<< ForestType      Maximum Time Since Disturbance
<< -----
                    5      10      9999
<<
                    Suitability Values
<< -----
Pine                2      1      0
MapleHardwood      0      0      0
SpruceFir           0      0      0
Other               0      0      0
```



### 3. Output Files

The Local Habitat Suitability output extension generates a series of suitability maps for each suitability file provided (see section 2.1.5). Output maps are generated at a frequency determined by the OutputTimestep (see section 2.1.2). All non-active sites will have values of 0 in the output maps.

## 4. Sample Input Files

### 4.1. Main Parameter File

```

LandisData LocalHabitatSuitability
Timestep 1
OutputTimestep 10

MapFileNames      output/habitat/{HabitatName}-{timestep}.img

SuitabilityFiles   ageclass_foresttype_example.txt
                   ageclass_tsd_example.txt
                   foresttype_tsd_example.txt

```

### 4.2. Habitat Suitability Input Files

#### 4.2.1. AgeClass\_ForestType

```

LandisData      HabitatSuitabilityFile
HabitatName     species1

SuitabilityType AgeClass_ForestType

ReclassCoefficients
>> Species      ReclassCoeff
>> -----      -
pinubank        1.0
pinuresi        1.0
pinustro        1.0
acersacc        1.0
betualle        1.0
abiebals        0.5
acerrubr        0.5
fraxamer        0.5
piceglau        1.0
picemari        1.0
poputrem        0.5
betupapy        0.5

ForestTypeTable
>> Forest Type      Species
>> -----      -
Pine                pinubank pinuresi pinustro
MapleHardwood       acersacc betualle abiebals acerrubr fraxamer -pinubank

```

```
SpruceFir      piceglau picemari abiebals
Other          poputrem betupapy
```

```
SuitabilityTable
<< ForestType      Maximum Age Values
<< -----      -----
                10      30      999
<<                Suitability Values
<< -----
Pine            0      1      2
MapleHardwood  0      0      1
SpruceFir      0      0      1
Other          0      0      0
```

### 4.2.2. AgeClass\_TimeSinceDisturbance

```
LandisData      HabitatSuitabilityFile
HabitatName     species2
```

```
SuitabilityType AgeClass_TimeSinceFire
```

```
DisturbanceTable      Fire
<< Severity Class SuitabilityWeight
0                      0
1                      0
2                      0
3                      0
4                      1
5                      1
```

```
SuitabilityTable
<< MaxTimeSinceFire      Maximum Age Values
<< -----      -----
                10      30      999
<<                Suitability Values
<< -----
5                1      2      3
10               0      1      2
9999             0      0      1
```

### 4.2.3. DisturbedForestType\_TimeSinceDisturbance

```
LandisData      HabitatSuitabilityFile
HabitatName     species3
```

```
SuitabilityType DisturbedForestType_TimeSinceFire
```

ReclassCoefficients

```
>> Species      ReclassCoeff
>> -----      -
pinubank        1.0
pinuresi        1.0
pinustro        1.0
acersacc        1.0
betualle        1.0
abiebals        0.5
acerrubr        0.5
fraxamer        0.5
piceglau        1.0
picemari        1.0
poputrem        0.5
betupapy        0.5
```

ForestTypeTable

```
>> Forest Type      Species
>> -----      -
Pine                pinubank pinuresi pinustro
MapleHardwood       acersacc betualle abiebals acerrubr fraxamer -pinubank
SpruceFir           piceglau picemari abiebals
Other               poputrem betupapy
```

DisturbanceTable Fire

```
<< Severity Class SuitabilityWeight
0                0
1                0
2                0
3                0
4                1
5                1
```

SuitabilityTable

```
<< ForestType      Maximum Time Since Disturbance
<< -----      -
                    5      10      9999
<<                Suitability Values
<< -----      -
Pine               2      1      0
MapleHardwood     0      0      0
SpruceFir         0      0      0
```

Other	0	0	0
-------	---	---	---