LANDIS-II-Site v2.4
User Guide

LANDIS-II Tool

Brian R. Miranda
Brian R. Sturtevant

USDA Forest Service
Northern Research Station

Last Revised: October 27, 2016

Table of Contents

1   Introduction

This document describes the **LANDIS-II-Site** tool for use with the LANDIS-II model. For information about the model and its core concepts, see the *LANDIS-II Conceptual Model Description.*

1.1 Installation

LANDIS-II-Site does not require formal installation; it can be run directly using the executable file (LANDIS-II-Site_V2.4.exe). However, the program requires all of the .dll and .netmodule files from the Zip to be located in the same folder as the executable file when it is run.

1.2 Major Releases

1.2.1 Version 2.4

Version 2.4 includes a bug fix related to the calculation of "development mortality". This version includes the equation as applied in v3.2 of Biomass Succession:

$$M_{BIOij} = ANPP_{MAXi} \times \frac{2 \times B_{APij}}{(1 + B_{APij})} \times B_{PMij}$$

This version also includes a bug fix related to the calculation of initial cohort biomass. This version includes the equation as applied in v3.2 of Biomass Succession:

$$InitialBiomass = ANPP_{MAXi} \times Exp\left(-1.6 \times B_{SUM} / B_{MAX-ECOREGION}\right)$$

Version 2.4 has also dropped the option of Succession Method v3.5, which was for developmental testing purposes only.

This version includes the option to record and/or manually set the random number seed (see 2.11.4).

1.2.2 Version 2.3

Version 2.3 includes a name change for this utility tool. The previous name of SiteVegetationCalculator has been replaced by LANDIS-II-Site. The version numbers have continued to maintain the full lineage of this tool. In this User Guide, the tool is sometimes referred to as the Calculator.

Version 2.3 increases the number of possible species to 6. Also, additional control over cohort removals has been added so that removals can impact only the oldest cohort, or all cohorts equally.

1.2.3 Version 2.2

Version 2.2 adds the function of vegetative reproduction for each of the species. This functionality requires 3 additional species parameters (vegetative reproduction probability, minimum resprout age, and maximum resprout age). The change in parameters means saved species files from previous versions will not work. To modify old saved files to work with the new version, add the 3 lines of text representing the new parameters between the lines representing Woody Decay Rate and ANPP Max.

Version 2.2 also includes a bug fix that caused erroneous behavior when a timestep of 1 year was selected.

1.2.4 Version 2.1

Version 2.1 provides the final version of Biomass V3.5 along with Biomass V3.0 and Age Class Succession.   A "Range" option has been added so that for certain parameters, multiple values can be run and graphed together. The ability to remove a cohort (partially of fully) at a given time has been added. Users can simulate up to 4 species starting with this version. Additional options for output have been added, and species parameters can now be saved and loaded from text files.

1.2.5 Version 2.0

Version 2.0 includes the final versions of Biomass V2 (2.1) and an early version of Biomass-LAI, as well as a Competition Comparison method that allows users to compare different forms of competition. The input parameters have been reorganized, parameters no longer used have been removed, and a new planting option has been added to allow the user to "plant" a cohort at any time in the simulation.

1.2.6 Version 1.1

This version expands the capabilities of version 1.0 to simulate up to 3 species, expands the graphic and log output, offers different succession methods, and other options to expand the utility of the tool.

1.2.7 Version 1.0

The original version of this tool is Version 1.0. Revisions and enhancements of this tool will be denoted by increasing version numbers.

1.3 Minor Releases

1.3.1 Version 2.4.1

This version fixes a bug in the calculation of initial biomass when using a 1-year timestep and multiple cohorts establish in the same timestep. This was Issue #4 in Biomass Succession, which was resolved at Version 3.2.2.

1.3.2 Version 2.3.1

This version fixes 2 minor bugs in the interface. The first bug fix is the disabling of the input text box MaturityAge for Species 6 when Biomass Succession is selected. The second bug fix is to allow decimal values to be entered for leaf longevity, which were previously restricted to integer values.

1.4 References

LANDIS-II Documentation Online:
   http://www.landis-ii.org/documentation.

LANDIS-II Age-Only Succession v3.0 Extension User Guide:
   http://www.landis-ii.org/extensions/age-only-succession

LANDIS-II Biomass Succession v3.2 Extension User Guide:
   http://www.landis-ii.org/extensions/biomass-succession

1.5 Acknowledgments

Valuable contributions to the development of this tool were made by Robert M. Scheller and Michael J. Papaik.

2 Tool Description

2.1 Overview

The LANDIS-II-Site tool is designed to simulate succession on a single site using the same shade and succession algorithms that are used in LANDIS-II. The simulation runs for a defined number of years with the option of having additional cohorts establishing based on defined establishment probabilities and shade class rules. Users can define whether a species is present at the beginning of the run, at what time seeds become available for each species, and at what time cohorts are planted. LANDIS-II-Site is can simulate up to 6 species and can simulate Age-Only Succession, Biomass Succession v3.2. The program automatically graphs species biomass, percent shade, shade class, number of cohorts, cohort ANPP, cohort biomass, and dead woody biomass by species. Some outputs are not generated with Age-Only Succession. Multiple simulations can be run and graphed together, with each simulation represented by a randomly selected unique color (except in batch mode). An optional log file can also be created for each simulation run recording some of the same data as the graphs.

2.2 Assumptions

LANDIS-II-Site uses several important simplifying assumptions:

- Dispersal distance from outside seed sources is not considered; seeds can always reach the simulated site once the Seed Availability Year has been reached.
- Succession and shade rules for the succession method determine growth, death, and additional establishment.
- The site experiences no disturbances for the duration of the simulation.
- Planting a cohort at a specified year does not follow the shade establishment rules. When a cohort is planted, it will always establish.

2.3 Simulation Parameters

2.3.1 Number of Species to Simulate

The user can choose to simulate up to 6 species at a time. The program identifies which species to simulate based on the Spp Numbers listed under the Species Parameters. For example, if the user chooses to simulate 2 species, the model will use the species labeled with Spp Numbers 1 and 2, regardless of their order in the table.

2.3.2 Simulation Years

The Simulation Years defines the length of time the simulations should be run.

2.3.3 Timestep

The Timestep defines the time interval between attempts to establish. Succession runs growth calculations at an annual timestep, but establishment years are controlled by the input Timestep.

2.3.4 Removal

Users can choose between 2 options for how removals are applied. "Oldest Cohort" will cause removals to only impact the oldest cohort of a species. For example, a 0.5 removal using "Oldest Cohort" will remove 50% of the oldest cohort's biomass. "All Cohorts" will cause removals to equally impact all cohorts of the species. For example, a 0.5 removal using "All Cohorts" will remove 50% of each cohort's biomass.

2.4 Succession Method

2.4.1 Age-only

This method uses succession functions that are used in the released Age-only Succession V3.0.

2.4.2 Biomass V3.2

This method uses the growth and mortality functions that are used in the released Biomass Succession V3.2.

2.5 Output Options

2.5.1 Output Log

The Calculator will produce an output log for each run if the user checks the box labeled "Output Log" or by selecting "Output Log" from the "Options" menu. See section 3.2 for details of the Output Log.

2.5.2 Graph Legend

The Calculator will provide a legend for each graph, identifying the run number for each graphed line, if the user keeps the box labeled "Graph Legend" checked. The legends can be turned off by unchecking the box or deselecting "Graph Legend" in the "Options" menu. It is recommended that the legends be turned off when running many replicate runs (especially Batch Mode), because the legend takes space away from the graphs as it grows in size.

2.5.3 Batch Mode

A batch mode that runs multiple replicates using the same input values can be turned on by selecting "Batch Mode" in the "Options" menu or by checking the box labeled "Batch". When Batch Mode is selected, a box appears in the Output Options box where the user can specify how many replicates to run. All of the replicates will be graphed as they run, and will create output logs for each replicate if Output Log is checked. It is highly recommended that users turn off the Graph Legends when using Batch Mode. Graphed lines in Batch Mode appear as semi-transparent black (species 1), blue (species 2), red (species 3), magenta (species 4), green (species 5) or cyan (species 6) lines which darken in places where multiple replicates coincide.

2.5.4 Range Mode

When Batch Mode is selected, the option of using Range Mode becomes available. Range Mode allows multiple values of certain variables to be run sequentially and graphed together within 1 run of the calculator. Range Mode can be turned on by checking the box labeled Range. When Range Mode is selected, a single check box appears next to the parameters ANPP Max, Mortality Shape, Growth Shape, Prop Mort, and Age Mort. Only one parameter can be selected for range mode on each run. Choose a range parameter by checking one of those boxes. Range mode will run multiple replicates for each

parameter value as it does in batch mode, so you may wish to set the number of replicates as well.

When you click RUN while in Range Mode, a popup box will appear asking for the values of the range parameter. Users should enter a lower value (defaults to value in the main form), an upper value, and an increment between the two. For example, if the values entered were 2 for lower value, 5 for upper value, and 0.5 for increment, the model would run simulations with the parameter set to 2, 2.5, 3, 3.5,…,5.

The output in Range Mode appears in the graphs with a predefined color scheme. The output from the lowest parameter value appears as green, the output from the highest parameter value appears as red, and output from parameter values in between are represented by a mixed color scaled proportionately between green and red colors. The output in Range Mode also used the same semi-transparent display scheme as Batch Mode, so that areas that overlap multiple times are darker. As with Batch Mode, it is recommended that the Graph Legend option be turned off when using Range Mode, as the legend can become large reduce the size of the output graphs.

2.5.5 Add Reference

Reference values can be added as points to any output graph. Clicking the 'Add Reference' button opens a new form that allows users to choose a text file with the reference data, and the output graphs to which those reference points should be added. The reference text file should be a space delimited text file, with column headings. The first column should represent the age or year and have a heading of 'Age', and the second column should represent the output values. The second column should also have a heading, but it does not have to be named anything specific.

2.5.6 Output Folder

When Output Log is selected, you can direct the output logs to be written to a specific folder. If no output folder is specified, the logs will be written to the location that contains the LANDIS-II-Site executable file.

2.6 Species Parameters

Species parameters are attributes that apply to all cohorts of a species, across all ecoregions (in a LANDIS-II simulation). These attributes

are equivalent to those found in the LANDIS-II species attribute file
and the succession parameter file (SpeciesParameters Table).

2.6.1 Spp Number

The Spp Number identifies which species will be simulated if the
Number of Species to Simulate is less than 4. The Spp Numbers also
correspond to the numbering of species in the graph legends.

2.6.2 Longevity

Maximum age the species can reach.

2.6.3 Shade Tolerance

Shade tolerance class (1-5).

2.6.4 Maturity Age (Age-Only)

Age of sexual maturity.

2.6.5 Leaf Longevity (Biomass only)

Number of years that leaves remain on a tree. This is used to
differentiate woody biomass from leaf biomass. For deciduous species
this value should be 1.

2.6.6 Woody Decay Rate (Biomass only)

The rate of decay (proportion/year) that woody biomass decays.

2.6.7 Vegetative Reproduction Probability

The probability that a cohort killed by disturbance reproduces
vegetatively (resprout). Establishment of a resprouted cohort is not
subject to the species establishment probability. Vegetative
reproduction is subject to shading rules (light availability).

2.6.8 Minimum Resprout Age

The minimum age at which a cohort can reproduce vegetatively.

2.6.9 Maximum Resprout Age

The maximum age at which a cohort can reproduce vegetatively.

2.7 Species/Ecoregion Parameters

Ecoregion-dependent species parameters are attributes that apply to a
specific combination of species and ecoregion. When simulating

dynamics on different ecoregions, these parameter values can vary. These attributes are equivalent to those found in the LANDIS-II succession Dynamic Input file.

2.7.1 ANPP Max (Biomass only)

The maximum ANPP for the species on the specific ecoregion. A lower productivity site would have a lower maximum ANPP value.

2.7.2 Biomass Maximum (Biomass only)

The maximum biomass that the species can reach on the specific ecoregion. A lower productivity site would have a lower maximum biomass value.

2.7.3 Mortality Shape parameter (Biomass only)

The Mortality Shape Parameter controls the timing and intensity of age-related mortality. The parameter determines when age-related mortality begins and can prevent the cohort from reaching its potential maximum biomass.

2.7.4 Growth Shape parameter (Biomass only)

Parameter that determines the steepness of the ANPP curve.

2.8 Species Establishment Rules

2.8.1 Establishment Probability

The species establishment probability determines the probability of establishment of a new cohort during each timestep. Where the establishment probability is greater than 0, a cohort will establish if both shade conditions allow AND a uniform random number (0-1) is less than or equal to the establishment probability.

User Tip: Simulations using this tool are deterministic if establishment probabilities are either 0 or 1, but are stochastic for any values between 0 and 1. Probabilities of 0 show the growth and death of a single cohort through time. A species that is not present at the start of the simulation will never appear if it has an establishment probability of 0, unless planted (see below). Probabilities of 1 show the growth and continual establishment of additional cohorts, as long as the shade conditions allow establishment.

2.8.2 Seed Availability Year

Users can make seed unavailable for all or part of the simulation time for each species. New cohorts cannot establish by seeding (resprout is still possible) for any year which is less than the Seed Avail. Year for a given species.

2.8.3 Planting Year

A cohort can be forced to establish at a given timestep regardless of shade or establishment probability (see note below). If a planting year is provided that falls between 0 and the end simulation year and falls during a timestep (multiple of Timestep) then a single cohort of that species will be established at that time. The establishment of a cohort by planting will replace a cohort that otherwise would have established by other means rather than result in two cohorts being added. The default values for this parameter are 0, to have any simulated species establish at year 0. Any negative value for Planting Year means that no planting of the species occurs.

Note: The establishment rule for planting within LANDIS-II-Site varies slightly from how it works in LANDIS. In the Calculator, planting can be successful even if the establishment probability is 0. In LANDIS, establishment probability must be > 0 for planting to be successful. This difference is intentional in order to maximize the control of cohort establishment within the Calculator.

2.8.4 Removal Year

Users can force a cohort to be removed prior to its longevity by specifying a removal year. Removals only impact the oldest cohort of a given species in the year specified. The removal can completely remove (kill) the cohort, or remove a portion of its biomass. A negative value for Removal Year means that no removal of the species occurs.

2.8.5 Removal Prop

A removal can remove any proportion of a cohort's biomass, from 0 to 1. A complete removal of biomass (1) kills the cohort (and triggers potential vegetative reproduction). Removal of less than all of the biomass allows the cohort to remain living and sets its biomass to some proportion of what it was. The removed biomass is assumed to remain on site and goes into the dead biomass pool. When using Age-

only Succession, if Removal Prop is greater than 0, the entire oldest cohort is removed.

2.9 Sufficient Light Table (Biomass only)

These modifiers are used to influence the establishment probability based on the shade tolerance and actual shade class. When the modifier is less than 1.0, the probability of establishment is multiplied by the modifier before testing for establishment.

2.10 Shade Class Thresholds

The shade class thresholds define the rules that are used to categorize the shade class of a site. The parameters and methods are different for Age-only and Biomass Succession.

2.10.1 Age-only Succession

The shade class is determined by the shade tolerance of the species present on the site, with only cohort above the age of maturity contributing to shade. The Shade Class Thresholds are not used with Age-only Succession.

2.10.2 Biomass Succession

Shade class is determined based on biomass relative to the maximum site biomass. The parameters represent the minimum relative biomass (%) required for a site to be each shade class. For example, the default value for shade class 1 is 15. Therefore, if the biomass of a site is less than 15% of the maximum biomass, it would be assigned shade class 0. If the biomass is greater than 15%, but below the threshold for shade class 2 (default 30), then it would be assigned shade class 1.

The default parameters define that only species with shade tolerance 5 can establish if the site shade class is equal to the shade tolerance class. All other species can only establish if site shade class is less than the species shade tolerance.

The Landscape Biomass Maximum specifies the maximum species biomass across all species in the ecoregion. If all species are simulated, this parameter is not necessary. However, it provides a method for accurately tracking shade even if the species with the highest biomass is not simulated in a given calculator run.

2.11 Control Buttons

2.11.1 RUN

The RUN button runs simulation(s) with the currently selected options and input values.

2.11.2 Quit

The Quit button exits LANDIS-II-Site and closes the program.

2.11.3 Clear Graphs

The Clear Graphs button clears all existing lines from all graphs, and resets the simulation counter to 0.

2.11.4 Random Number Seed

The tool will automatically record in the text box the random number seed that was applied during the last execution of the tool. To control the random number seed, check the Random Number Seed check box. Whenever the checkbox is checked, the tool will use the number provided in the text box as the random number seed. Multiple runs with the same random number seed will have identical results even when stochastic processes are running (e.g., establishment probabilities). Users can synchronize simulations across multiple computers by using the same random number seeds.

2.12 Saving and Loading Species Parameters

Species and Species/Ecoregion parameters can be saved to a text file and loaded from saved text files. Under the File menu option are options for Save Parameters and Load Parameters. The Species Establishment Rules and the Shrub options are not saved with the species parameters.

2.12.1 Save Parameters

In the Save Parameters menu option are separate options to save Species 1, 2, 3, 4, 5 or 6. The Species number corresponds to Spp Number in the calculator interface. When a species is selected for saving, a menu will appear to either enter a filename (with full path) or browse to a location and filename. Files should be saved in a standard text file format (.txt).

2.12.2 Load Parameters

In the Load Parameters menu option are separate options to load Species 1, 2, 3, 4, 5 or 6. The Species number corresponds to Spp Number in the calculator interface. The values in the interface for the chosen species number will be overwritten with the loaded values. When a species number is selected for loading, a menu will appear to enter a filename (with full path) or browse to a location and filename. Files being loaded should be in a standard text file format (.txt).

3 Output

3.1 Output Graphs

The simulation output is automatically displayed on 7 graph tabs on the bottom portion of the tool. The different graphs can be viewed by clicking on the tabs with the output names. Each time the simulator is run, a new line(s) (up to 6) will be added to each graph with a new randomly selected color. The legend tracks the order in which the simulations were run. Multiple species will be represented by the same color for each run, but use different line symbols (solid thick for species 1, solid thin for species 2, thin dotted for species 3, thick dotted for species 4, thin dashed for species 5, thick dashed for species 6). All graphs can be cleared by clicking the 'Clear Graphs' button. The simulation numbers in the legend (and the numbering of log files) start over at 1 after the graphs are cleared.

For any graph that is created, users can identify actual values on the graph by right-clicking on the graph and selecting Show Point Values. Graphs can also be saved, copied, or printed by using the context menu that appears when right-clicking on a graph.

Users can zoom in on a portion of a graph by clicking and dragging the crosshairs on the graph to define the area in which to zoom. Zooming can be undone using the context menu that appears when right-clicking on a graph.

3.1.1 Biomass (Biomass only)

Aboveground biomass (kg/ha) for each species. Any single species is denoted by a solid line. If multiple species are simulated, Species 1 is denoted by a thick solid line, Species 2 is denoted by a solid thin line, Species 3 is denoted by a thin dotted line, Species 4 is denoted by a thick dotted line, Species 5 is denoted by a thin dashed line, and Species 6 is denoted by a thick dashed line.

3.1.2 Percent Shade (Biomass only)

Relative shade for the site. Shade contributions all species are combined to calculate site percent shade.

3.1.3 Shade Class

The resulting shade class (0-5) calculated by the chosen succession method. Shade class influences establishment according to the appropriate succession rules and inputs.

3.1.4 Number of Cohorts

Number of cohorts for each species. Count of 10-year age cohorts for each simulated species. Any single species is denoted by a solid line. If multiple species are simulated, Species 1 is denoted by a thick solid line, Species 2 is denoted by a solid thin line, Species 3 is denoted by a thin dotted line, Species 4 is denoted by a thick dotted line, Species 5 is denoted by a thin dashed line, and Species 6 is denoted by a thick dashed line.

3.1.5 Cohort ANPP (Biomass only)

ANPP for each cohort. If multiple species are simulated, Species 1 is denoted by a thick solid line, Species 2 is denoted by a solid thin line, Species 3 is denoted by a thin dotted line, Species 4 is denoted by a thick dotted line, Species 5 is denoted by a thin dashed line, and Species 6 is denoted by a thick dashed line. Multiple cohorts of the same species appear as multiple lines with the same representation

3.1.6 Cohort Biomass (Biomass only)

Total biomass for each cohort. If multiple species are simulated, Species 1 is denoted by a thick solid line, Species 2 is denoted by a solid thin line, Species 3 is denoted by a thin dotted line, Species 4 is denoted by a thick dotted line, Species 5 is denoted by a thin dashed line, and Species 6 is denoted by a thick dashed line. Multiple cohorts of the same species appear as multiple lines with the same representation

3.1.7 Dead Wood (Biomass only)

Total dead woody biomass for the site.

3.2 Output Log

The simulation output that is graphed is also automatically saved in a text log file. The log file can be written to a specific folder using the Output Folder option, or the file(s) is saved to the location from which

the LANDIS-II-Site program was run. The log file is in comma-delimited format (.csv) and is names "Out#.csv", where # represents the run number. Each time the simulator is run, a new log file will be created. Note that clearing the graphs resets the counting of runs, and therefore subsequent log files will overwrite previous log files.

4 Input Values

The input parameters for this tool are specified within the textboxes of the tool. Users must manually type the parameter values into the boxes in the user interface. Default values represent realistic sample values for a landscape in Labrador, Canada, and are meant primarily to demonstrate an appropriate input format. See the Users Guides for the different Succession versions for details regarding input values. Generally, the input values come from 2 standard input files for LANDIS-II: the species input file, and the succession input file.

Input values can be reset to their default values by closing and reopening the program. There is no way to save a set of parameter values to reuse.

4.1 Species Number

The "Spp Number" inputs must be 1, 2, 3, 4, 5 and 6 in any order. In all output, the species identified with Spp Number 1 will always be identified as Species 1. If the Number of Species to Simulate is greater than 1, then the species are included in the order of Spp Number. For example, if 2 species are chosen to simulate, the species used will be those with Spp Number 1 and 2, no matter what their order in the input.