LANDIS-II DAMM GIPL SHAW (DGS) Succession v1.0

Extension User Guide

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# Introduction

This document describes the **Damm-McNIP, SHAW and GIPL (DGS, pronounced 'Digs') Succession** extension for the LANDIS-II model. For information about the LANDIS-II model and its core concepts including succession, see the *LANDIS‑II Conceptual Model Description* and the LANDIS-II website (www.landis-ii.org)*.*

## Purpose

Here we developed a new succession extension (DGS Succession) of the LANDIS-II forest landscape model that integrates a vegetation dynamics model (NECN) with a soil carbon model (DAMM-McNiP), a physically-based hydrologic model (SHAW), and a deep soil profile permafrost model (GIPL) in a spatially-explicit framework. The new module simulates: (1) tree and shrub growth, mortality, and reproduction, (2) carbon and nitrogen dynamics of seven soil pools that are measurable in the field, (3) energy and water fluxes (e.g. snow depth, evapotranspiration, soil moisture) at multiple levels in both the canopy and soil, and (4) soil temperature (i.e. permafrost dynamics) down to 75 m.

For a schematic drawing of the NECN extension, see Lucash et al in review at Ecological Modelling.

## Cohort Reproduction – Probability of Establishment

Identical to NECN, the probability of establishment (PEST) is internally calculated at an annual time step and is dependent upon input weather data. Although calculated annually, establishment can only occur following a disturbance or at a succession time step. PEST is based on the minimum of three limiting factors: 1) growing degree days (GDD), 2) drought tolerance, 3) minimum January temperature. These represent **site-scale** limits to species establishment in that the requisite parameters vary by ecoregion. Available light is calculated as a function of LAI (via the MaximumLAI table, described below) and is included as a part of the **site scale** limits to establishment.

## Cohort Growth

At each time step, cohort growth is determined by estimated leaf area index (LAI), water availability based on SHAW algorithms, soil temperature based on GIPL, growing space capacity and nitrogen availability. Cohort growth generally follows the algorithms found in NECN, except that water and temperature limitations to growth are calculated by SHAW and GIPL, respectively.

## Soil and Dead Biomass Decay

Decay processes follow the algorithms from DAMM McNiP (Abramoff et al., 2017). DAMM-McNiP tracks seven pools: soil organic C (SOC) and N (SON), dissolved organic C (DOC) and N (DON), microbial biomass C and N, and extracellular enzymes (Abramoff et al., 2017). Litter inputs are partitioned evenly between soil organic matter (SOM) and dissolved organic matter (DOM) pools each month for both C and N.

Soil CN pools are responsive to changes in soil temperature, soil moisture, oxygen concentrations, and substrate CN stoichiometry. Temperature affects the rate of SOM depolymerization to DOM using Arrhenius kinetics. Soil water content modiﬁes the supply of oxygen and DOM, both of which affect depolymerization using a Michaelis Menten (i.e., dual Monod) kinetic approximation. Oxygen concentration limits the depolymerization rate when soil water content is high, while the litter inputs limit depolymerization when soil water content is low, because the substrate cannot diffuse to the reaction site. Microbial uptake is limited by both DOC and DON substrate and oxygen concentration using M-M kinetics with uptake partitioned in the microbial pool between maintenance, growth, and enzyme production. Enzyme production can be limited by stoichiometry of microbial C or N.

## Initializing Biomass and Soil Properties

The initial biomass is provided by the user and therefore there is no model “spin-up”.

**Note:** *An initial (time zero) climate stream is still required for initialization (see the climate library user’s manual- LANDIS-II Climate Library v4.2 User Guide). This is an artifact of the Climate Library and this data is not used.*

**The user MUST supply the initial biomass estimates for each cohort.** This is described below.

## Interactions with Disturbances

DGS provides an interface to dead biomass for SCRPPLE, but has not been tested with the other disturbance extensions.

## Available Light

Available light (the conceptual inverse of shade) calculations uses cumulative LAI to determine the amount shade.

## Cohort Reproduction – Disturbance Interactions

See the rules and algorithm outlined for Biomass Succession (v2).

## Cohort Reproduction – Initial Biomass

See the rules and algorithm outlined for Biomass Succession (v2).

## Cohort Senescence

See the rules and algorithm outlined for Biomass Succession (v2).

## Major Releases

### Version 1.0 (April 2022)

This is the first official release of DGS.

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# Succession Input File

Many of the input parameters for DGS are specified in the main input file. Additional files are required for species and functional group parameters. 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*.

## LandisData

This parameter’s value must be "DGS Succession".

## Timestep

This parameter is the time step of the extension. Value: integer > 0. Units: years.

**Note**: When changing the timestep of this extension (e.g., from a 5-year time step to a 1-year time step), you may need to adjust the probability of establishment adjustment factor (ProbEstablishAdjust) to retain the same regeneration rates (see section 2.13 below).

## SeedingAlgorithm

This parameter indicates the seeding algorithm. Valid values are "WardSeedDispersal", "NoDispersal" or "UniversalDispersal". The algorithms are described in section 4.5.1 *Seeding* of the *LANDIS‑II Conceptual Model Description*.

## InitialCommunities (file name)

This parameter is the file with the definitions of the initial communities at the active sites on the landscape (see section 4).

## InitialCommunitiesMap (file name)

This parameter is the input map indicating the initial communities at the active sites on the landscape. Each cell value for an active site on the landscape must be one of the map codes listed in the initial communities input file (see section 4).

## ClimateConfigFile (file name)

The climate configuration file contains required climatic inputs. The format of that file and its contents are described in the climate library user’s manual (LANDIS-II Climate Library v1.0 User Guide).

## SoilDepthMapName (double)

The depth of the soil simulated, cm.

**User Tip:** The depth specified here has a large influence on soil water holding capacity.

## SoilDrainMapName (double)

Determines the amount of water runoff and leaching. This affects the amount of N leaching (N loss) which, in turn, affects the amount of mineral N.

* Drain: the fraction of excess water lost by drainage. The soil drainage factor allows a soil to have differing degrees of wetness (e.g., [DRAIN](http://www.nrel.colostate.edu/projects/century/manual4/man96.html#DRAIN)=1 for well drained sandy soils and [DRAIN](http://www.nrel.colostate.edu/projects/century/manual4/man96.html#DRAIN)=0 for a poorly drained clay soil).

## SoilBaseFlowMapName (double), SoilStormFlowMapName (double)

Determines the amount of water runoff and leaching. This affects the amount of N leaching (N loss) which, in turn, affects the amount of mineral N.

* BaseFlow: the fraction per month of subsoil water going into stream flow
* StormFlow: the fraction of the soil water content lost as fast stream flow

## SoilFieldCapacityMapName (double), SoilWiltingPointMapName (double)

Field capacity and wilting point expressed as a fraction (range from 0.0 to 1.0). In the model algorithms, field capacity and wilting point are calculated as this fraction multiplied by soil depth.

## SoilPercentClayMapName (double), SoilPercentSandMapName (double)

Percent clay and sand are expressed as a fraction (0.0 – 1.0).

## InitialSOM1CsurfMapName (double)

The initial (time 0) amount of C in the soil surface, typically assumed to include the humus layer (g C m-2).

## InitialSOM1NsurfMapName (double)

The initial (time 0) amount of N in the soil surface (g N m-2).

## InitialSOM1CsoilMapName (double)

The initial (time 0) amount of C in the soil sub-surface; SOM1 indicates that this is the most labile C (g C m-2).

## InitialSOM1NsoilMapName (double)

The initial (time 0) amount of N in the soil sub-surface (g N m-2).

## InitialSOM2CMapName (double)

The initial (time 0) amount of C in the ‘slow’ soil pool (SOM2) (g C m-2).

## InitialSOM2NMapName (double)

The initial (time 0) amount of N in the ‘slow’ soil pool (SOM2) (g N m-2).

## InitialSOM3CMapName (double)

The initial (time 0) amount of C in the ‘passive’ soil pool (SOM3) (g C m-2).

## InitialSOM3NMapName (double)

The initial (time 0) amount of N in the ‘passive’ soil pool (SOM3) (g N m-2).

## InitialDeadWoodSurfaceMapName (double)

The initial (time 0) amount of surficial dead woody material, e.g., logs (g Biomass m-2).

## InitialDeadWoodSoilMapName (double)

The initial (time 0) amount of belowground dead woody material, e.g., dead roots (g Biomass m-2).

## CalibrateMode (Optional)

Determines whether the model is run in calibrate mode whereby additional parameters are added to a log file (“NECN-calibrate-log.csv”). **The calibrate mode should only be used when simulating a single site due to the volume of model output in the calibrate log file.** The intention is to view output of additional parameters, such as what factors are limiting growth at each time step.

## SmokeModelOutputs (Optional)

These are outputs specific to subsequent (external) calculations of smoke emissions. If true, maps of conifer needle biomass, surface dead wood, and SOM1-surface (litter) are produced.

## Version\_Henne\_SoilWater (Optional)

A Boolean input (Y or N). If true, a new version of the soil water calculations (provided by Dr. Paul Henne, USGS) are used for soil water calculations.

## WaterDecayFunction

The WaterDecayFunction parameter determines the effect of moisture on decay rate can be either linear or based on a ratio. The Century 4.0 Help file states that linear option is to be when only the relative water content in the top 15 cm affects decay rates. If ratio, the ratio of rainfall to potential evaporation rate determines the effect of moisture on decay rates.

Options: “Linear” or “Ratio”

***User Tip:*** *Linear is generally appropriate for sandy soils; ratio for more mesic soils.*

## ProbabilityEstablishAdjust (double)

This optional parameter adjusts the probability of establishment. The default value is one.

***User Tip:*** *This value can be reduced (<1) if overall regeneration rates are too high. Keep in mind that p-est is dependent on the successional time step. For example, you might want to lower the adjustment factor if you shift from a 5-year time step to a 1-year time step.*

## InitialMineralN (double)

The amount of mineral N (g m-2).

## InitialFineFuels (double)

The amount of fine fuel biomass (internally, the SoilStructural and SoilMetabolic layers) as a fraction of initial dead wood. This accounts for recent disturbance that may have deposited large volumes of both dead wood and fine fuels. Ranges from 0.0 to 1.0.

## Nitrogen Inputs: Slope and Intercept

Determines N deposition rates (including wet deposition, dry deposition, non-symbiotic fixation and N fertilization) using simple regression:

Total N deposition = (AtmosNslope\*precipitation) + AtmosNinter

The AtmosNslope parameter controls how the amount of wet deposition, i.e. how much N is deposited during rain events, with higher slopes generating more N deposition. Dry deposition is controlled by the N intercept parameter, which is constant and is not a function of precipitation.

**User Tip:** *Adjust the slope and intercept until the monthly or annual N deposition in the NECN-succession-monthly-log.csv is similar to literature values.*

## Latitude

The latitude of the study site (°).

## DenitrificationRate

The fraction of mineral N lost through ammonia volatilization and denitrification **per month**. This fraction is not fire related; fire related volatilization is modeled separately. Ranges from 0.0 to 1.0.

**User Tip:** *This parameter should be adjusted so that Nvol (output parameter of N volatilization) ranges from 0 to ~0.3 for uplands and 0.3 to 1 g m-2 year-1 for wetlands (Seitzinger et al. 2006).*

## DecayRateSurf

The maximum decay rate for the SOM1-surface pool and the maximum decay rates for foliar structural material. Prior to v6.6, the maximum decay rate for foliar structural material was fixed at 0.39 monthly.

## Decay Rates of SOM1, SOM2, and SOM3 soil pools

The decay rates for SOM1-surface, SOM1-soil, SOM2, and SOM3 determine the **maximum** decomposition rate (k) of the four soil organic matter pools. Ranges from 0.0 to 1.0.

**User Tip:** *In most landscapes, the relative changes in the soil pools are higher in the upper than the lower horizons. Therefore, the maximum decay rates should be higher in the surficial than the deeper pools (i.e. DecayRateSurf>DecayRateSOM1> DecayRateSOM2>DecayRateSOM3). Also, the total amount of C in soil should slowly increase over time in the absence of disturbance.*

## CreateInputCommunityMaps (Optional)

This Boolean keyword will create maps necessary for generating new initial conditions in a separate model run. Maps include: SOM1, SOM2, SOM3, DeadRoots. Other necessary inputs are provided elsewhere.

## GrassThresholdMultiplier (Optional)

The parameter that adjusts the competitive relationship between grasses and trees (positive number, double). The competitive relationship between tree species cohort *i* is calculated by the following algorithm.

|  |
| --- |
| if then    else    end if |
|  |

## MaximumLAI Table

The MaximumLAI table defines how much Leaf Area Index must be at a site to achieve the five available light classes (in previous extensions, ‘shade classes’). LAI is cumulative at a site. The table contains the maximum LAI required for each available light class, 1 - 5.

### Available Light Class

This column contains available light class values: 1 ≤ integer ≤ 5. The classes must be in increasing order: class 1 first and ending with class 5. Available light class 5 represents the least light (most shade). A site will be class 0 (complete light) if LAI ranges from 0 up to the maximum LAI (%) for class 1. Likewise, if maximum LAI is between the amount defined for classes 1 and 2, the site is given an available light class of 1. And so on up to class 5.

### Maximum LAI

Each light class has an associated maximum LAI. Value: 0.0 ≤ decimal number ≤ 20.0.

## LightEstablishmentTable

This table allows the user to control site-scale PEST dependent upon species light requirements (i.e., shade class) and available light. For example, if a species is mid-tolerant of low light (light requirement = 3) and the available light class is 5 (very low light), the probability may be low but not zero. If the user indicates a low probability, then there would still some small chance that a mid-tolerant can become established as may be the case in small gaps.

### Species Shade Tolerance Class

This column contains light requirement (shade) class values: 1 ≤ integer ≤ 5. The classes must be in increasing order: class 1 first and ending with class 5. Class 5 represents species with the lowest light requirements, i.e., the most shade tolerant.

### Probability of Establishment, given light conditions

Each possible site-level light condition (0 – 6) has an associated probability for each species light requirement class (1 – 5). Value: 0.0 ≤ decimal number ≤ 1.0.

## SpeciesParameters (CSV file name)

This table contains species’ physiological parameters. Each row in the table has the parameters for one species. Every active species must have an entry.

**A CSV file of species parameters MUST be provided; the older style text inputs are no longer supported.** Every column must have a heading, spelled and with capitalization exactly as listed below. The type (integer, double, Boolean, or string) of the data must match the expected type, indicated in parentheses.

### SpeciesCode (string)

The species code must be defined in the species input file (see chapter 5 in the *LANDIS‑II Model User Guide*). Species code may appear in any order.

### FunctionalType (integer)

This is an index into the FunctionalTypeParameters table, below.

### NitrogenFixer (boolean)

This should be either TRUE or FALSE, depending on whether the species can fix N. An N fixing tree or shrub is never N limited and its N components fertilize following mortality.

### GDDMinimum (integer), GDDMaximum (integer)

Growing Degree Day (GDD) maximum and minimum are used to define a species climatic envelope following the algorithm by Botkin (1973). GDD is calculated on a 5°C base.

### MinJanuaryT (integer)

A species has a minimum tolerable January temperature (the mean of January nights). If the stochastically generated January minimum temperature is below the minimum, a species cannot establish. Units: degrees Celsius.

### MaxDrought (double)

If available water falls below zero for a percent of the growing season greater than this value, a species cannot establish. Units: fraction of the growing season (0.0 – 1.0). Lower values indicate species whose establishment is more sensitive to drought.

### LeafLongevity (integer)

This parameter is the average longevity of a leaf or needle. Value: 1 ≤ integer number ≤ 10. Units: years.

### Epicormic (boolean)

Does the species resprout via epicormic branching following a fire? Value: TRUE or FALSE.

### LeafLignin (double), FineRootLignin (double), WoodLignin (double), CoarseRootLignin (double)

The fraction of lignin in each plant component (leaf, fine root, wood, and coarse root) per species. Value: 0.0 ≤ decimal number ≤ 1.0.

### LeafCN (double), FineRootCN (double), WoodCN (double), CoarseRootCN (double), FoliageLitterCN (double)

The carbon to nitrogen ratios for leaf, fine root, wood, coarse root, and litter components. The difference between leaf and litter CN ratios represents the amount of N that is resorbed (i.e. retranslocated) prior to leaf mortality.

**Note**: *For retranslocation to work properly, litter CN* ***must be*** *higher than leaf CN for each species.*

### MaximumANPP (integer)

This parameter is the maximum possible aboveground net primary productivity (ANPP) for each cohort of each species. The value is specified as the ANPP in the month of the year with maximum growth (e.g., June). Value: 0 ≤ integer ≤ 100,000. Units: g biomass m-2 month-1. Default value: 0.

**Note:** This parameter is in units of biomass but output from Landis-NECN is in units of C (C generally comprises roughly 50% of biomass).

**Note:** This is the maximum monthly ANPP during peak growing season, not the annual ANPP often reported in the literature.

### MaximumBiomass (integer)

This parameter defines the maximum allowable aboveground biomass (AGB) for each species. This is a life history attribute and determines the overall growth form of a species (shrub vs. understory vs. overstory) as determined by evolutionary history. This parameter interacts with KLAI and ANPP to determine the growth rate and maximum biomass of each species. Value: 0 ≤ integer. Units: g biomass m-2. Default value: 0.

### GrowthLAI (double)(optional)

Determines the LAI growth limit, i.e., the relationship between LAI and growth limits, using the equation:

LAI\_Growth\_limit = Maximum(0.0, 1.0 - e(GrowthLAI \* LAI))

The default value is 0.47.

### Grass (boolean)

This parameter should be either TRUE or FALSE, depending on whether the species is grass species or not. If users include grass species in their simulation, competition relationships between grasses and trees will be computed by the algorithm shown in 2.31. If users simulate only tree species, this parameter should be set to FALSE for all species.

## FunctionalGroupParameters (CSV file name)

These parameters are either not generally resolved to the level of species or are similar across genera. **The number of functional groups cannot exceed 25.**

**A CSV file of functional group parameters MUST be provided; the older style text inputs are not supported**. Every column must have a heading, spelled and with capitalization exactly as listed below. The type (integer, double, Boolean, or string) of the data must match the expected type, indicated in parentheses.

### FunctionalGroupName (string)

The name is for display purposes only to help users organize their inputs.

### FunctionalTypeIndex (integer)

An index to the species table.

### TemperatureCurve1 (double), TemperatureCurve2 (double), TemperatureCurve3 (double), TemperatureCurve4 (double)

These four parameters define how growth will respond to temperature and are used to define a Poisson Density Function curve. See the CENTURY references for a full explanation.

* Curve 1: The optimum temperature for growth.
* Curve 2: The maximum temperature for growth.
* Curve 3: The left curve shape parameter.
* Curve 4: The right curve shape parameter.

### FractionANPPtoLeaf (double)

The fraction of aboveground net primary productivity that is allocated to leaves. Units: fraction of ANPP (0.0 – 1.0).

### LeafBiomassTOLAI (double), KLAI (double), MaximumLAI (double)

These three parameters determine how LAI is calculated which subsequently limits growth. Therefore these parameters help determine the initial rate of growth in the landscape. BTOLAI determines LAI as a function of leaf biomass. KLAI and MAXLAI determine LAI as a function of wood biomass. If MAXLAI = 0.0, then only leaf biomass determines LAI and the growth limits.

* LeafBiomassToLAI: The leaf biomass to leaf area index (LAI) conversion factor for trees. This parameter determines the seasonal pattern of LAI for deciduous trees. It is not used for conifers.
* KLAI: The large wood mass (g C/m2) at which half of theoretical maximum leaf area [(maxlai)](http://www.nrel.colostate.edu/projects/century/manual4/man96.html#MAXLAI) is achieved.
* MaximumLAI: The theoretical maximum leaf area index for a cohort.

### MinimumLAI (double) (optional)

The minimum LAI for any given cohort. The default value is 0.1. An overly low minimum LAI may create the situation where a cohort is permanently suppressed under a closed canopy.

### MoistureCurve2 (double), MoistureCurve3 (double)

These two parameters determine growth sensitivity to low available water, e.g., drought conditions.

*Intercept = (moisturecurve2 \* soil water content*

*Slope = 1.0 / (moisturecurve3 - intercept*

*WaterLimit = 1.0 + slope \* (Ratio\_AvailWaterToPET - moisturecurve3)*

* Moisture2: Determines the intercept of the effect of water content on growth.
* Moisture3: Determines the lowest ratio of available water to potential evapotranspiration at which there is no restriction on production.

### WoodDecayRate (double)

This parameter defines the maximum fraction of the species’ dead wood that decomposes in the ecoregion. Value: 0.0 ≤ number ≤ 1.0. Unitless.

### MonthlyWoodMortality (double)

A monthly fraction of wood mortality, *constant through time and regardless of successional stage*. This mortality is in addition to growth-related mortality as a function of ANPP. Units: fraction of wood biomass (0.0 – 1.0).

### LongevityMortalityShape (double)

This parameter determines how quickly longevity-related mortality begins and operates as in Biomass Succession. Value: 5.0 ≤ decimal number ≤ 25.0. If the parameter = 5, then age-related mortality will begin at 10% of life span. If the parameter = 25, then age-related mortality will begin at 85% of life span.

### FoliageDropMonth (integer)

This parameter determines when the leaves will drop and become part of the litter pool. This parameter only applies to deciduous (Leaf longevity = 1.0 vegetation); evergreen species drop an equal amount of foliage across all months.

**Note:** *Note that FoliageDropMonth=9 means that half the leaves will drop in October (one month offset) and the other half drop in November.*

### CoarseRootFraction (double), FineRootFraction (double)

The fraction of aboveground net primary productivity that is used to compute the ANPP of coarse and fine roots. Units: fraction of ANPP (0.0 – 1.0).

## Fire Reduction Parameters

The FireReductionParameters table allows users to specify how much dead wood and litter will be removed as a function of fire severity. The reduction of wood and litter will occur **after** fire induced mortality of cohorts. After a fire kills a cohort, the dead biomass is deposited on the forest floor and is then subsequently volatilized in the same time step.

**Note**: This table is required even if fire extensions are not being used.

### Fire Severity (integer)

The first column is fire severity, classes 1 – 10. Severity should be listed in ascending order.

**The number of fire severity classes that you should use is dependent on the fire extension selected.**

### Coarse Debris Reduction (double)

The second column is the proportion (0.0 – 1.0) of dead wood biomass that is volatilized. The proportion will be applied to both C and N components.

### Fine Litter Reduction (double)

The third column is the proportion (0.0 – 1.0) of dead litter biomass that is volatilized. The proportion will be applied to both C and N components.

### Cohort Wood Reduction (double)

The fourth column is the proportion (0.0 – 1.0) of cohort wood biomass that is volatilized. The proportion will be applied to both C and N components.

### Cohort Leaf Reduction (double)

The fifth column is the proportion (0.0 – 1.0) of cohort leaf biomass that is volatilized. The proportion will be applied to both C and N components.

### Organic Horizon Reduction (double)

The last column is the proportion (0.0 – 1.0) of SOM1-surface (the O-Horizon) that is volatilized. The proportion will be applied to both C and N components.

## Harvest Reduction Parameters

The HarvestReductionParameters table specifies how much dead wood and litter will be removed as a function of harvest activity ***and how much cohort wood and leaf biomass is moved off site during harvesting***. Live cohort wood is typically removed from the site during harvesting. After a harvest event kills a cohort, pre-existing dead biomass can be removed from the forest. If a prescription is not listed (or is not spelled identically to the name used in the harvest prescription file), the defaults are zero for all values.

### Prescription Name

The first column is prescription name. Each prescription name must be identical to the prescription names in the Harvest file (see “LANDIS-II Base Harvest v2.0 User Guide”). Prescriptions can be in any order; they do *not* need to appear in the same order as in the Harvest input file.

### Dead Wood Reduction (double)

The second column is the proportion (0.0 – 1.0) of dead wood biomass that is removed. The proportion will be applied to both C and N components.

### Dead Litter Reduction (double)

The third column is the proportion (0.0 – 1.0) of dead litter biomass that is removed. The proportion will be applied to both C and N components.

### Cohort Wood Removal (double)

The fourth column is the proportion (0.0 – 1.0) of cohort *living* wood biomass that is removed from the site. *The remainder is typically regarded as slash.* The proportion will be applied to both C and N components.

### Cohort Leaf Removal (double)

The fifth column is the proportion (0.0 – 1.0) of cohort *living* foliar biomass that is removed from the site. *The remainder is typically regarded as slash.* The proportion will be applied to both C and N components.

# Output Files

The NECN Succession extension produces a number of outputs. The maps of soil C, ANPP, and NEE are described above.

In Version 5+, additional maps have been added to track water:

* Annual Water Budget: Excess soil moisture after evapotranspiration. Defined as water inputs (precipitation + irract) – actual evapotranspiration (AET)
* Available water: amount of water available to trees

In addition to the maps, there are five primary log files and one optional log files. These are all comma delimited (\*.csv) files that are typically read using Excel.

## Output Metadata

When you run NECN, xml files are created for all text outputs in the Metadata folder**. Users can open these xml files in any internet browser and will list all the output parameters, their description and units.**

## NECN-succession-log

The primary log file that outputs a snapshot of data at every successional time step. These data are averaged by climate region and are most useful for analyzing variation over time and across climate regions.

## NECN-succession-log-short

An abbreviated version of the NECN-succession-log file. This reduced set of parameters was chosen for display in the LANDVIZ tool.

## NECN-succession-monthly-log

This log file contains an abbreviated set of data that are useful at a monthly time step. These include NPP, heterotrophic respiration, N deposition and NEE. These data can be compared to monthly flux tower data. Also included are monthly temperature and precipitation. These allow a quick cross-reference to your input data.

## NECN-prob-establish-log

This log file contains the data used to calculate the probability of ***seeding*** establishment for each climate region at each succession time step. The probability of establishment is the minimum of all limiting factors. However, these values do not take shade and presence of seed sources into account and therefore do not reflect the cumulative probability of establishment in a given site. These also do not reflect reproduction from planting, serotiny, or resprouting.

***Note:*** *The probability of establishment is calculated annually and averaged over the succession time step.*

## NECN-reproduction-log

This log file summarizes all reproduction events, including from planting, serotiny, resprouting, and seeding.

## NECN-calibrate-log (Optional)

A detailed monthly output for **every cohort at each month**. *Note:* ***Due to the volume of data, this file should ONLY be used with single cell runs.***

# Initial Communities Input File

This file contains the definitions of the initial community classes. Each active site on the landscape is assigned to an initial community class. The class specifies the tree species that are present along with the particular age classes and associated biomass (g m-2) that are present for each of those species.

## LandisData

This parameter’s value must be "Initial Communities".

## Initial Community Class Definitions

Each class has an associated map code and a list of species present at sites in the class. There are now two methods for inputting these data. A human-readable text files and a CSV file, each described below.

Both formats require map codes that correspond to the accompanying map, species, ages, and woody biomass (g m-2)

## CSV Community File Input

We developed the CSV format for when many hundreds or thousands of initial communities must be input. In this case, an easy-to-read format has less value and can be difficult to generate.

This format is compatible with the Biomass Community Output extension: succession extensions can directly read the outputs from Biomass Community Output using the CSV format.

### FileName (Optional)

This variable triggers the extension to accept either the CSV format or the older human-readable format. Both formats cannot be used at the same time.

The file name must point to a CSV file with format described next.

### CSV format

The CSV format requires a header with the following names: X, Y, Z.

Each row contains these data:

**MapCode**: This parameter is the code used for the community in the input map (see section ). Value: 0 ≤ integer ≤ 65,535. Each communities’ map code must be unique. Map codes do not have to appear in any order, and do not need to be consecutive.

**SpeciesName**: These must match the names found in the scenario species file.

**CohortAge**: A cohort age is an integer and must be between 1 and the species’ Longevity parameter. The ages do not have to appear in any order.

**CohortBiomass**: Biomass must be entered as an integer (no significant digits).

***For Empty Map Codes***: If there is an active map code that does not have any vegetation, the data should be represented as: *TheActualMapCode*, NA, 0, 0 (where *TheActualMapCode* is the code without data, e.g. 1968).

## Human-Readable Input File

We designed the easy-to-read format described below to allow people (versus computers) to visually assess community composition.

### MapCode

This parameter is the code used for the community in the input map (see section 2.5). Value: 0 ≤ integer ≤ 65,535. Each communities’ map code must be unique. Map codes do not have to appear in any order, and do not need to be consecutive.

### Species Present and Biomass

A list of species present at the class’ sites comes after the map code. Each species is listed on a separate data line.

*species age (biomass) age (biomass) age* *(biomass)*...

The species name comes first, followed by one or more ages and their associated **aboveground woody biomass** (g biomass m-2) in parentheses. The name and ages are separated by whitespace. An age is an integer and must be between 1 and the species’ Longevity parameter. The ages do not have to appear in any order.

acersacc 10 (240) 5 (16) 21 (769) 60 (1968) 100 (210)

Biomass must be entered as an integer (no significant digits) and **there must be a biomass associated with every cohort**.

The list may be empty, which will result in the sites in the class being initialized with no species cohorts.

## Example Files (CSV Format)

LandisData "Initial Communities"

CSVFileName MyCSVfile.csv

Example CSV File:

|  |  |  |  |
| --- | --- | --- | --- |
| MapCode | SpeciesName | CohortAge | CohortBiomass |
| 10 | PinuTaed | 50 | 100 |
| 10 | QuerAlba | 1 | 100 |
| 10 | AcerRubr | 1 | 100 |

## Example File (Human Readable Format)

LandisData "Initial Communities"

>>Old jackpine oak

MapCode 7

acerrubr 30 (204)

pinubank 80 (1968) 90 (15212)

pinuresi 110 (204) 140 (42)

querelli 40 (204) 120 (1968) 240 (47)

>> young jackpine oak

MapCode 0

pinubank 30 (204) 50 (2512)

querelli 10 (6) 40 (23) 70 (1968)

>> young aspen

MapCode 2

poputrem 10 (419) 20 (879)

### Grouping Species Ages into Cohorts

The list of ages for each species is grouped into cohorts based on the succession extension’s timestep. This timestep determines the size of each cohort. For example, if the timestep is 20, then the cohorts are ages 1 to 20, 21 to 40, 41 to 60, etc.

Suppose an initial community class has this species in its list (biomass left out here for simplicity):

acersacc 10 25 30 40 183 200

If the succession timestep is 10, then the cohorts for this species initially at each site in this class should be:

acersacc 10 20 30 40 190 200

Note that biomass values will be totaled when cohorts are grouped.

If the succession timestep is 20, then the cohorts for this species initially at each site in this class will be:

acersacc 20 40 200