# LANDIS-II DGS (**D**AMM-McNiP **G**IPL **S**HAW) Succession v1.0 Extension User Guide

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# 1 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).

## 1.1 Purpose

The DGS Succession Extension of the LANDIS-II forest landscape model 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 based on the NECN succession extension version 6.4, (2) carbon and nitrogen dynamics of seven soil pools that are measurable in the field based on DAMM-McNiP, (3) energy and water fluxes (e.g. snow depth, evapotranspiration, soil moisture) at multiple levels in both the canopy and soil based on SHAW, and (4) soil temperature (i.e. permafrost dynamics) down to 75 m based on GIPL.

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

**The DGS succession extension must be run with Scrpple (version 3.2.1.1) and the Output Reclass extension (version 3.1).**

## 1.2 Cohort Reproduction – Probability of Establishment

Identical to NECN version 6.4, the probability of establishment ($P_{EST}$) 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. $P_{EST}$ 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.

## 1.3 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. Also, cohort growth is limited at high water availability (similar to a temperature response curve), unlike NECN where growth levels off at high soil moisture.

## 1.4 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.

## 1.5 Initializing Biomass and Soil Properties

The initial biomass is provided by the user and therefore there is no model "spin-up". Initial soil temperature and water content are also provided by the user but the influence of these initial conditions extends to much shorter timescales than initial vegetation conditions typically required by LANDIS-II.

**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.

## 1.6 Interactions with Disturbances

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

## 1.7 Available Light

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

## 1.8 Cohort Reproduction – Disturbance Interactions

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

## 1.9 Cohort Reproduction – Initial Biomass

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

## 1.10 Cohort Senescence

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

## 1.11 Major Releases

### 1.11.1 Version 1.0 (April 2023)

This is the first official release of DGS.

## 1.12 References

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## 1.13 Acknowledgments

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# 2 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*.

## General Succession Parameters

### 2.1 LandisData

This parameter's value must be `"DGS Succession"`.

### 2.2 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).

### 2.3 CalibrateMode

Determines whether the model is run in calibrate mode whereby additional parameters are added to a log file ("DGS-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.

### 2.4 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 User Guide).

### 2.5 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 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 DGS-succession-monthly-log.csv is similar to literature values.*

## 2.6 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).

## 2.7 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).

## 2.8 Latitude

The latitude of the study site (°).

## 2.9 ShawGiplConfigFile (file name)

This refers to the file that contains the information about which files to use for SHAW and GIPL.

## 2.10 SoilDepthMapName (double)

The depth of the soil simulated, cm.

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

## 2.11 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=1 for well drained sandy soils and DRAIN=0 for a poorly drained clay soil).

## 2.12 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

## 2.13 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.

## 2.14 SoilPercentSandMapName (double), SoilPercentClayMapName (double)

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

## 2.15 SoilBulkDensityMapName (double)

Percent bulk density is expressed as a fraction (0.0 – 1.0).

## 2.16 SoilParticleDensityMapName (double)

Percent particle density is expressed as a fraction (0.0 – 1.0).

## 2.17 InitialSOC_PrimaryMapName (double)

The initial (time 0) amount of C in the soil profile down to the depth specified in map of soil depth (g C $m^{-2}$).

## 2.18 InitialSON_PrimaryMapName (double)

The initial (time 0) amount of soil N, profile down to the depth specified in map of soil depth (g N $m^{-2}$).

## 2.19 InitialDeadWoodSurfaceMapName (double)

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

## 2.20 InitialDeadCoarseRootsMapName (double)

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

# General Soil Parameters

## 2.21 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.

## 2.22 InitialMineralN (double)

The amount of mineral N (g $m^{-2}$).

## 2.23 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) matches empirical data (Seitzinger et al. 2006).*

## 2.24 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.*

# General DAMM-McNIP Parameters

## 2.25 InitialMicrobialC

This parameter determines the initial microbial C present in the soil

## 2.26 InitialMicrobialN

This parameter determines the initial microbial N present in the soil

## 2.27 InitialEnzymeConc

This parameter determines the initial enzyme concentration present in the soil

## 2.28 ActEnergySOMDepoly

This parameter determines the activation energy needed for SOM depolymerization.

## 2.29 ActEnergyDOCDepoly

This parameter determines the activation energy needed for DOC uptake.

## 2.30 ExpConstSOMDepoly

This parameter determines the pre-exponential constant for SOM depolymerization.

## 2.31 ExpConstDOCUptake

This parameter determines the pre-exponential constant for DOC uptake in the soil.

## 2.32 FractionSOMUnprotect

This parameter determines the fraction of unprotected SOM from decomposition (0-1).

## 2.33 CNEnzymes

This parameter determines the initial CN ratio of enzymes in the soil

## 2.34 KmSOMDepoly

This parameter determines the half-saturation constant for SOM depolymerization.

## 2.35 KmDOCUptake

This parameter determines the half-saturation constant for DOC uptake

## 2.36 EnzTurnRate

This parameter determines the initial enzyme turnover rate in the soil

## 2.37 MicrobialTurnRate

This parameter determines the initial microbial turnover rate in the soil

## 2.38 CarbonUseEfficiency

This parameter determines the initial carbon use efficiency in the soil

## 2.39 PropEnzymeSOM

This parameter determines the proportion of the enzyme pool acting on the SOM.

## 2.40 PropCEnzymeProduction

This parameter determines the proportion of assimilated C allocated to enzyme production

## 2.41 PropNEnzymeProduction

This parameter determines the proportion of N allocated to enzyme production

## 2.42 FractDeadMicrobialBiomassSOM

This parameter determines the fraction of dead microbial biomass allocated to SOM

## 2.43 MMConstantO2

This parameter determines the initial Michaelis-Menton constant for O2

## 2.44 DiffConstantO2

This parameter determines the diffusion coefficient for O2 in air.

## 2.45 DiffConstantSOMLiquid

This parameter determines the diffusion coefficient for unprotected SOM and DOM in liquid

## 2.46 FractionVolumeO2

This parameter determines the volume fraction of O2 in the air.

## 2.47 DOCFraction

This parameter determines the fraction of DOC present in the soil

## 2.48 DONFraction

This parameter determines the fraction of DON present in the soil

## 2.49 FractionLitterToDOC

This parameter determines the fraction of litter inputs which are composed of DOC

## 2.50 SoilMoistureA

This parameter determines the y intercept for the scalar function of soil moisture.

## 2.51 SoilMoistureB

This parameter determines the slope for the scalar function of soil moisture.

# General Dispersal and Establishment Parameters

## 2.52 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*.

## 2.53 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.*

## 2.54 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.

### 2.54.1 Available Shade Class

This column contains available shade class values: $1 \leq$ integer $\leq 5$. The classes must be in increasing order: class 1 first and ending with class 5. Available shade 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 shade class of 1. And so on up to class 5.

### 2.54.2 Maximum LAI

Each shade class has an associated maximum LAI. Value: $0.0 \leq$ decimal number $\leq 20.0$.

## 2.55 LightEstablishmentTable

This table allows the user to control site-scale $P_{EST}$ 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.

### 2.55.1 Species Shade Tolerance Class

This column contains light requirement (shade) class values: $1 \leq$ integer $\leq 5$. 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.

### 2.55.2 Probability of Establishment, given shade conditions

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

## 2.56 SpeciesParameters

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

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.

### 2.56.1 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.

### 2.56.2 FunctionalType (integer)

This is an index into the `FunctionalTypeParameters` table, below.

### 2.56.3 NitrogenFixer (boolean)

This should be either 'Y' (TRUE) or 'N' (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.

Adventitious Roots (Boolean)

This should be either 'Y' (TRUE) or 'N' (FALSE), depending on whether the species has adventitious roots and/or can access near-surface water when permafrost is present.

### 2.56.4 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.

### 2.56.5 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.

### 2.56.6 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.

### 2.56.7 LeafLongevity (integer)

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

### 2.56.8 Epicormic (boolean)

Does the species resprout via epicormic branching following a fire? Value: 'Y' (TRUE) or 'N' (FALSE).

### 2.56.9 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: $0.0 \leq$ decimal number $\leq 1.0$.

### 2.56.10 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.*

### 2.56.11 RootDepth (integer)

Maximum rooting depth (m) for each species. This determines the depth at which species can access available water.

### 2.56.12 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: $0 \leq$ integer $\leq 100{,}000$. Units: g biomass $m^{-2}$ $month^{-1}$. Default value: 0.

**Note:** This parameter is in units of biomass but output from Landis-DGS 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.

### 2.56.13 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: $0 \leq$ integer. Units: g biomass $m^{-2}$. Default value: 0..

## 2.57 FunctionalGroupParameters

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.**

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.

### 2.57.1 FunctionalGroupName (string)

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

### 2.57.2 FunctionalTypeIndex (integer)

An index to the species table.

### 2.57.3 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.

### 2.57.4 FractionANPPtoLeaf (double)

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

### 2.57.5 BTOLAI (double), KLAI (double), K (double), MaximumLAI (double)

These four 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.

- BTOLAI: 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 even if a value is specified in the table.
- KLAI: The large wood mass (g $C/m^2$) at which half of theoretical maximum leaf area (maxlai) is achieved.
- K: 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.
- MaximumLAI: The theoretical maximum leaf area index for a cohort.

### 2.57.6 MoistureCurve1 (double), MoistureCurve2 (double), MoistureCurve3 (double), MoistureCurve4 (double)

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

- Curve 1: The optimum soil moisture for growth.
- Curve 2: The maximum soil moisture for growth.
- Curve 3: The left curve shape parameter.
- Curve 4: The right curve shape parameter.

### 2.57.7 WoodDecayRate (double)

This parameter defines the maximum fraction of the species' dead wood that decomposes in the ecoregion. Value: $0.0 \leq$ number $\leq 1.0$. Unitless.

### 2.57.8 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).

### 2.57.9 LongevityMortalityShape (double)

This parameter determines how quickly longevity-related mortality begins and operates as in Biomass Succession. Value: $5.0 \leq$ decimal number $\leq 25.0$. 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.

### 2.57.10 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*.

### 2.57.11 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).

## 2.58 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.

### 2.58.1 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.**

### 2.58.2 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.

### 2.58.3 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.

### 2.58.4 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.

### 2.58.5 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.

### 2.58.6 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.

## 2.59 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.

### 2.59.1 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.

### 2.59.2 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.

### 2.59.3 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.

### 2.59.4 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.

### 2.59.5 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.

# 3 SHAW/GIPL Input Files

The DGS Succession extension uses SHAW to simulate hydrology and energy balance and GIPL to simulate soil temperature with files specified in the GeneralShawGIPLConfig file. See references for more details on how to parameterize the input files below. Whenever a SHAW input is directly used without modification, the relevant SHAW variable name is provided in the input template files. More details on the SHAW model is available at: https://www.ars.usda.gov/pacific-west-area/boise-id/northwest-watershed-research-center/docs/shaw-model/, with a user's manual at: https://www.ars.usda.gov/ARSUserFiles/20520500/SHAW/ShawUsers.30x.pdf

Descriptions of SHAW variables that are used without modification are omitted from the following descriptions of input files.

## 3.1 ListThus (file name)

This csv file contains all the information about all the initial conditions for the THUs. It includes the following columns, for which a value must be assigned for each THU:

THUNumber: arbitrary number assigned to each THU

THUName: descriptive name for each THU

ReclassVegetation: Vegetation reclassification into different vegetation types based on LANDIS-II reclass extension

VegetationType1: Determines which vegetation type from ShawPlantTypes should be used

VegetationType2: Optional second vegetation type to be included from ShawPlantTypes

MinAge/MaxAge: Defines the minimum and maximum age of vegetation in LANDIS-II outputs for which a cell should be assigned to each THU

MinSlope/MaxSlope: As with age. The effective slope used in SHAW is the midpoint between these two values. Value is determined by Scrpple.

Aspect: Aspect class for which cells from LANDIS-II should be assigned to a THU. Options include North, South, Other (East or West), and are assigned if a cell slope is within 45° of a given direction. Value is calculated by Scrpple.

MinSand/MaxSand: Defines minimum and maximum sand content for which a LANDIS-II cell should be assigned to a given THU. Actual sand value used in SHAW is defined in ShawSoilTypes.

MinSilt/MaxSilt: As with sand.

MinLatitude/MaxLatitude: As with slope.

MinElevation/MaxElevation: As with slope.

MaxSnowThickness: Used to determine maximum snow thickness for GIPL.

SnowNodes: Determines number of nodes used for snow calculations in GIPL.

InitSnowTemperature: Initial snow temperature for GIPL

ShawSoilTypeN (where N represents the layer number): Defines soil type for lookup from ShawSoilTypes

GiplSoilTypeN: Defines soil type for lookup from GiplProperties; should align with ShawSoilType1 but these two models take different input soil parameters.

MaxDepthN: Maximum depth of the nth layer

NodesN: Number of nodes for finite difference calculations in SHAW in each soil layer

InitTemperatureN: Initial soil temperature for layer N

InitWaterContent: Initial water content for layer N

## 3.2 ShawGeneralInputs (file name)

This csv file contains all the information about all the general conditions for the landscape. For each parameter, the SHAW variable name is provided (capitalized, preceded by #) for cross-reference with the SHAW documentation. Output file names (e.g. LVLOUT(1)) and the selection of which variables are output can be defined here.

## 3.3 ShawPlantTypes (file name)

This csv file contains all the information about all the vegetation conditions for the landscape to be used in SHAW. The PlantName column is cross-referenced from the THU file (values should match exactly). LeafOnDay and LeafOffDay each define days of the year at which LAI begins to accumulate or decline, respectively, with a 30-day period until reaching maximum or zero LAI. For non-deciduous trees, set LeafOnDay to 1 and LeafOffDay to 366. Other variables in this file are explicitly defined in the SHAW documentation.

## 3.4 ShawSoilTypes (file name)

This csv file contains all the information about all the soil conditions for the landscape to be used in SHAW. As with the ShawPlantTypes, the "Name" column is provided for cross-reference with the THU file. Other variables are defined in SHAW.

## 3.5 GiplProperties (file name)

This csv file contains all the information about all the initial conditions for GIPL, including the geothermal heat flux (units?), WCritical (definition and units?), SnowC1 (def and units). The input file also contains a table with rows for each layer type (e.g. live moss), its thermal conductivity (units?), volumetric heat capacity (units?) and a file name that contains a txt file with the volumetric unfrozen liquid water fraction (see section 3.6.

## 3.6 Unfrozen.txt (file name)

# 4 Output Files for DGS

The DGS Succession extension produces a number of outputs, including of Aboveground ANPP (AG_NPP), Available Water (down to the average rooting depth of the species in a cell), LAI, Mineral N, NEE (net ecosystem exchange), THU (temperature hydrologic unit), and Total C

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.

## 4.1 Output Metadata

When you run DGS, 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.**

## 4.2 DGS-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.

## 4.3 DGS-succession-log-short

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

## 4.4 DGS-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.

## 4.5 DGS-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.*

## 4.6 DGS-reproduction-log

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

## 4.7 DGS-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.***

# 5 Output Files for SHAW

SHAW produces a subfolder for each THU. Each folder contains eight output files. Details of the contents of these output files are provided in the SHAW documentation referenced above. Each is a text file containing some header information, followed by a tabular data format with a time series of data values for the model run, at each node for the soil variables or for the site for other variables.

## 5.1 energy. out

Timeseries of energy balance components.

## 5.2 snow. out

Timeseries of snow depth and water equivalent and soil ice content. Timesteps with no snow or soil ice content are omitted from the file.

## 5.3 soilliquid. out

Timeseries with soil liquid water content at each node.

## 5.4 soilmatric. out

Timeseries with soil matric potential at each node.

## 5.5 soiltemp. out

Time series with soil temperature at each node.

## 5.6 soilwater. out

Time series with soil volumetric water content (liquid and frozen) at each node.

## 5.7 water. out

Water balance time series.

# 6 Output Files for GIPL

GIPL produces two output files for each THU.

## 6.1 Log_THUNumber_Snow. csv

Output from GIPL which lists the year, month, day, snow thickness (m), snow thermal conductivity (W/m/K), and snow volume heat capacity (J/m3/K)

## 6.2 Log_THUNumber. txt

Output from GIPL in txt form.

# 7 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.

## 7.1 LandisData

This parameter's value must be `"Initial Communities"`.

## 7.2 Initial Community Class Definitions

Each class has an associated map code, a list of species present at sites in the class, their ages and biomass (g $m^{-2}$)

### 7.2.1 MapCode

This parameter is the code used for the community in the input map (see section 2.7). Value: $0 \leq$ integer $\leq 65{,}535$. Each communities' map code must be unique. Map codes do not have to appear in any order, and do not need to be consecutive.

### 7.2.2 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.

## 7.3 Example File

```
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)
```

### 7.3.1 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
```