

LANDIS-II DGS (**D**AMM-**M**cNiP **G**IPL **S**HAW) Succession v2.0 Extension User Guide

Melissa S. Lucash¹
Adrienne Marshall²
Dmitry Nicolsky³
Shelby Weiss¹

¹University of Oregon, Eugene, OR

²Colorado School of Mines, Colorado Springs, CO

⁴University of Alaska, Fairbanks, AK

Last Revised: July 8, 2025

Table of Contents

1	INTRODUCTION	4
1.1	Purpose	4
1.2	Cohort Reproduction – Probability of Establishment	4
1.3	Cohort Growth	4
1.4	Soil and Dead Biomass Decay	5
1.5	Initializing Biomass and Soil Properties	5
1.6	Interactions with Disturbances	5
1.7	Available Light	5
1.8	Cohort Reproduction – Disturbance Interactions	6
1.9	Cohort Reproduction – Initial Biomass	6
1.10	Cohort Senescence	6
1.11	Major Releases	6
1.11.1	Version 2.0 (July 2025)	6
1.11.2	Version 1.0 (April 2023)	6
1.12	References	6
1.13	Acknowledgments	8
2	SUCCESSION INPUT FILE	9
	General Succession Parameters	9
2.1	LandisData	9
2.2	Timestep	9
2.3	CalibrateMode	9
2.4	ClimateConfigFile (file name)	9
2.5	Nitrogen Inputs: Slope and Intercept	9
2.6	InitialCommunities (file name)	10
2.7	InitialCommunitiesMap (file name)	10
2.8	Latitude	10
2.9	ShawGiplConfigFile (file name)	10
2.10	SoilDepthMapName (double)	10
2.11	SoilDrainMapName (double)	10
2.12	SoilBaseFlowMapName (double), SoilStormFlowMapName (double)	10
2.13	SoilFieldCapacityMapName (double), SoilWiltingPointMapName (double)	11
2.14	SoilPercentSandMapName (double), SoilPercentClayMapName (double)	11
2.15	SoilBulkDensityMapName (double)	11
2.16	SoilParticleDensityMapName (double)	11
2.17	InitialSOC_PrimaryMapName (double)	11
2.18	InitialSON_PrimaryMapName (double)	11
2.19	InitialDeadWoodSurfaceMapName (double)	11
2.20	InitialDeadCoarseRootsMapName (double)	11
	General Soil Parameters	11
2.21	InitialFineFuels (double)	11
2.22	InitialMineralN (double)	12
2.23	DenitrificationRate	12
2.24	WaterDecayFunction	12
	General DAMM-McNIP Parameters	12
2.25	InitialMicrobialC	12
2.26	InitialMicrobialN	12
2.27	InitialEnzymeConc	12
2.28	ActEnergySOMDepoly	12
2.29	ActEnergyDOCDepoly	12
2.30	ExpConstSOMDepoly	13
2.31	ExpConstDOCUptake	13

2.32	FractionSOMUnprotect	13
2.33	CNEnzymes	13
2.34	KmSOMDepoly	13
2.35	KmDOCUptake	13
2.36	EnzTurnRate	13
2.37	MicrobialTurnRate	13
2.38	CarbonUseEfficiency	13
2.39	PropEnzymeSOM	13
2.40	PropCEnzymeProduction	13
2.41	PropNEnzymeProduction	13
2.42	FractDeadMicrobialBiomassSOM	14
2.43	MMConstantO2	14
2.44	DiffConstantO2	14
2.45	DiffConstantSOMLiquid	14
2.46	FractionVolumeO2	14
2.47	DOCFraction	14
2.48	DONFraction	14
2.49	FractionLitterToDOC	14
2.50	SoilMoistureA	14
2.51	SoilMoistureB	14
	General Dispersal and Establishment Parameters	14
2.52	SeedingAlgorithm	14
2.53	ProbabilityEstablishAdjust (double)	15
2.54	SpeciesParameters	15
2.55	Fire Reduction Parameters	19
2.55.1	<i>Fire Severity (integer)</i>	19
2.55.2	<i>Coarse Debris Reduction (double)</i>	20
2.55.3	<i>Fine Litter Reduction (double)</i>	20
2.55.4	<i>Cohort Wood Reduction (double)</i>	20
2.55.5	<i>Cohort Leaf Reduction (double)</i>	20
2.55.6	<i>Organic Horizon Reduction (double)</i>	20
2.56	Harvest Reduction Parameters	20
2.56.1	<i>Prescription Name</i>	20
2.56.2	<i>Dead Wood Reduction (double)</i>	20
2.56.3	<i>Dead Litter Reduction (double)</i>	21
2.56.4	<i>Cohort Wood Removal (double)</i>	21
2.56.5	<i>Cohort Leaf Removal (double)</i>	21
3	SHAW/GIPL INPUT FILES	22
3.1	ListThus (file name)	22
3.2	ShawGeneralInputs (file name)	23
3.3	ShawPlantTypes (file name)	23
3.4	ShawSoilTypes (file name)	23
3.5	GiplProperties (file name)	24
3.6	Unfrozen.txt (file name)	24
4	OUTPUT FILES FOR DGS	25
4.1	Output Metadata	25
4.2	DGS-succession-log	25
4.3	DGS-succession-log-short	25
4.4	DGS-succession-monthly-log	25
4.5	DGS-prob-establish-log	25
4.6	DGS-reproduction-log	26
4.7	DGS-calibrate-log (Optional)	26
5	OUTPUT FILES FOR SHAW	27

5.1	energy. out	27
5.2	snow. out	27
5.3	soilliquid. out	27
5.4	soilmatric. out	27
5.5	soiltemp. out	27
5.6	soilwater. out	27
5.7	water. out	27
6	OUTPUT FILES FOR GIPL	28
6.1	Log_THUNumber_Snow. csv	28
6.2	Log_THUNumber. txt	28
7	INITIAL COMMUNITIES INPUT FILE	29
7.1	FileName	29
7.2	CSV file format	29
7.3	Example File	30

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 Social Climate Fire v4.01 and the Output Reclass extension (version 4.0).

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 (see Section 1.3 in NECN manual), except that water and

temperature limitations to growth are calculated by SHAW and GIPL, respectively.

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 2.0 (July 2025)

DGS was updated to version 8.0 of the LANDIS-II Core. The following updates were included:

- The species CSV table and functional group tables were merged into a single species CSV table
- A new algorithm determines whether there is sufficient light for establishment. The previous tables of LAI and shade classes have been replaced with two species parameters that determine a Weibull distribution that directly relates LAI to the probability of light given LAI (more details on pg 8 of the NECN manual).

1.11.2 Version 1.0 (April 2023)

This is the first official release of DGS.

1.12 References

Aber, J.D., D.B. Botkin, and J.M. Melillo. 1979. Predicting the effects of different harvesting regimes on productivity and yield in northern hardwoods. *Canadian Journal of Forest Research* **9**: 10-14.

Abramoff, R.Z., Davidson, E.A., Finzi, A.C., 2017. A parsimonious modular approach to building a mechanistic belowground carbon and nitrogen model. *J. Geophys. Res. Biogeosciences* **122**, 2418–2434

Albaugh, T., H. Allen, and L. Kress. 2006. Root and stem partitioning of *Pinus taeda*. *Trees - Structure and Function* **20**:176-185.

Botkin, D.B., J.F. Janak, and J.R. Wallis. 1973. Some ecological consequences of a computer model of forest growth. *Journal of Ecology* **60**: 849-872

Covelo, F., J. Duran, and A. Gallardo. 2008. Leaf resorption efficiency and proficiency in a *Quercus robur* population following forest harvest. *Forest Ecology and Management*.

Flerchinger, G. N., T. G. Caldwell, J. Cho, and S. P. Hardegree. “Simultaneous Heat and Water (SHAW) Model: Model Use, Calibration, and Validation.” *Transactions of the ASABE* **55**, no. 4 (2012): 1395–1411. <https://doi.org/10.13031/2013.42250>.

- Flerchinger, G.N., Cooley, K.R., 2000. A ten-year water balance of a mountainous semi-arid watershed. *J. Hydrol.* 237, 86–99.
- Flerchinger, G.N., Reba, M.L., Link, T.E., Marks, D., 2016. Modeling temperature and humidity profiles within forest canopies. *Agric. For. Meteorol.* 213, 251–262.
- Flerchinger, G.N., Saxton, K.E., 1989b. Simultaneous heat and water model of a freezing snow-residue-soil system II. Field verification. *Trans. ASAE* 32, 573–576.
- Johnson, D. W., M. E. Fenn, W. W. Miller, and C. T. Hunsaker. 2009. Fire effects on carbon and nitrogen cycling in forests of the Sierra Nevada. Pages 405–423 in A. Bytnerowicz, M. Arbaugh, C. Andersen, and A. Riebau, editors. *Wildland Fires and Air Pollution. Developments in Environmental Science* 8. Elsevier, The Netherlands.
- Killingbeck, K. T. 1996. Nutrients in senesced leaves: Keys to the search for potential resorption and resorption proficiency. *Ecology* 77:1716–1727.
- Lovett, G. M., L. M. Christenson, P. M. Groffman, C. G. Jones, J. E. Hart, and M. J. Mitchell. 2002. Insect defoliation and nitrogen cycling in forests. *BioScience* 52:335–341.
- Lovett, G. M. and A. E. Ruesink. 1995. Carbon and nitrogen mineralization from decomposing gypsy moth frass. *Oecologia* 104:133–138.
- Kimmins, J. P., D. Mailly, and B. Seely. 1999. Modelling forest ecosystem net primary production: the hybrid simulation approach used in FORECAST. *Ecological Modelling* 122:195–224.
- Marchenko, S., Romanovsky, V., Tipenko, G., 2008. Numerical modeling of spatial permafrost dynamics in Alaska, in: *Proceedings of the Ninth International Conference on Permafrost*. Institute of Northern Engineering, University of Alaska Fairbanks, pp. 1125–1130.
- Nicolsky, D.J., Romanovsky, V.E., Alexeev, V.A., Lawrence, D.M., 2007. Improved modeling of permafrost dynamics in a GCM land-surface scheme. *Geophys. Res. Lett.* 34, 2–6.
- Pan, Y., J.M. Melillo, A.D. McGuire, D.W. Kicklighter, L.F. Pitelka, K. Hibbard, L.L. Pierce, S.W. Running, D.S. Ojima, W.J. Parton, D.S. Schimel, and VEMAP Members. 1998. Modeled responses of terrestrial ecosystems to elevated atmospheric CO₂: a comparison of simulations by the biogeochemistry models of the Vegetation /Ecosystem Modeling and Analysis Project (VEMAP). *Oecologia* 114: 389–404.
- Park, B., R. Yanai, T. Fahey, S. Bailey, T. Siccama, J. Shanley, and N. Cleavitt. 2008. Fine root dynamics and forest production across a calcium gradient in northern hardwood and conifer ecosystems. *Ecosystems* 11:325–341.
- Ryan, D. F. and F. H. Bormann. 1982. Nutrient resorption in northern hardwood forests. *BioScience* 32:29–32.
- Scheller, R. M., D. Hua, P. V. Bolstad, R. A. Birdsey, and D. J. Mladenoff. 2011. The effects of forest harvest intensity in combination with wind disturbance on carbon dynamics in Lake States mesic forests. *Ecological Modelling* 222:144–153.
- Scheller, R.M., S. Van Tuyl, K. Clark, J. Hom, I. La Puma. 2011. Carbon sequestration in the in the New Jersey pine barrens under different scenarios of fire management. *Ecosystems*. DOI: 10.1007/s10021-011-9462-6
- Scheller, R. M. and Mladenoff, D. J. A forest growth and biomass module for a landscape simulation model, LANDIS: Design, validation, and application. *Ecological Modelling*. 2004; 180(1):211–229.

- Schimel, D.S., B.H. Braswell, E.A. Holland, R. McKeown, D.S. Ojima, T.H. Painter, W.J. Parton, and A.R. Townsend. 1994. Climatic, edaphic, and biotic controls over storage and turnover of carbon in soils. *Global Biogeochemical Cycles* 8: 279-293.
- Sergueev, D., Tipenko, G., Romanovsky, V., Romanovskii, N., 2003. Mountain permafrost thickness evolution under influence of long-term climate fluctuations (results of numerical simulation), in: *Proceedings of the VII International Permafrost Conference*, Switzerland. pp. 21–25.

1.13 Acknowledgments

Funding for the development of LANDIS-II has been provided by the U.S. Forest Service. Funding for DGS version 1.0 has been provided by NSF Arctic Program.

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:

$$\text{Total N deposition} = (\text{AtmosNslope} * \text{precipitation}) + \text{AtmosNinter}$$

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 SpeciesParameters

This csv file 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. Except for the first column (SpeciesCode), the order of the columns is not fixed and they can be in any order

Table 1. Parameters in the species input csv file and their keywords and descriptions.

Column Name	Input type	Description
SpeciesCode	string	The species code must be defined in the species input file. Species code may appear in any order.
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. Must be TRUE or FALSE.
GDDMinimum	integer	Growing Degree Day (GDD) minimum are used to define a species climatic envelope following the algorithm by Botkin (1973). GDD is calculated on a 5°C base. <i>Only applies to establishment.</i>
GDDMaximum	integer	Growing Degree Day (GDD) maximum are used to define a species climatic envelope following the algorithm by Botkin (1973). GDD is calculated on a 5°C base. <i>Only applies to establishment.</i>
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. <i>Only applies to establishment.</i>

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. <i>Only applies to establishment.</i>
LeafLongevity	integer	This parameter is the average longevity of a leaf or needle. Value: $1 \leq \text{integer number} \leq 10$. Units: years.
Epicormic	boolean	Does the species resprout via epicormic branching following a fire? Must be TRUE or FALSE.
LeafLignin	Double	The fraction of lignin in each plant component (leaf, fine root, wood, and coarse root) per species. Value: $0.0 \leq \text{decimal number} \leq 1.0$.
FineRootLignin	Double	The fraction of lignin.
WoodLignin	Double	The fraction of lignin.
CoarseRootLignin	double	The fraction of lignin.
LeafCN	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.
FineRootCN	Double	The carbon to nitrogen ratio.
WoodCN	Double	The carbon to nitrogen ratio.
CoarseRootCN	Double	The carbon to nitrogen ratio.
FoliageLitterCN	double	The carbon to nitrogen ratio. Note: <i>For retranslocation to work properly, litter CN must be higher than leaf CN for each species.</i>
MaximumANPP	integer	The maximum monthly 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: $0 \leq \text{integer} \leq 100,000$. Units: g biomass m ⁻² month ⁻¹ . Default value: 0. 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 KLAJ and ANPP to determine the growth rate and maximum biomass of each species. Value: $0 \leq \text{integer}$. Units: g biomass m^{-2} . Default value: 0.
GrowthLAI (optional)	double	Determines the LAI growth limit, i.e., the relationship between LAI and growth limits, using the equation: $\text{LAI_Growth_limit} = \text{Maximum}(0.0, 1.0 - e(\text{GrowthLAI} * \text{LAI}))$ The default value is 0.47.
Grass	boolean	Determines whether the species is grass species or not. If users include grass species in their simulation, there will be competition between grasses and trees (see Introduction). If users simulate only tree species, this parameter should be set to FALSE for all species. Must be TRUE or FALSE.
Nlog_depend	boolean	Determines whether the regeneration of species depends on nursery logs. If users include nursery log dependent species in their simulation, the establishment of these species cohorts is determined by environmental conditions, light probabilities, and the amount of well decayed downed logs. See Hotta et al. (2021) for details. Must be TRUE or FALSE.
LightLAIScale	double	The mean ('Scale') LAI of a Weibull distribution, determined from empirical data for each species. Must be > 0.0 .
LightLAIShape	double	The dispersion ('Shape') of a Weibull distribution, determined from empirical data for each species. These parameters use actual LAI to estimate the probability of light establishment from a probability distribution function.
LightLAILocation	double	The y-intercept ('Location') of a Weibull-like distribution, determined from empirical data for each species.
LightLAIAdjust	Double	A scaling parameter that multiplies probability of light establishment for that species. This may be used to increase the probability of establishment to better replicate previously calibrated parameters from NECNv6 or v7, or to represent species with

		greater fecundity. Note that using either LightLAIlocation or LightLAIAdjust will create a distribution that is no longer a probability density function: that is, the area under the curve will no longer sum to 1. However, it may better represent empirical data.
TemperatureCurve1	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. Curve1: The optimum temperature for growth.
TemperatureCurve2	double	Curve 2: The maximum temperature for growth.
TemperatureCurve3	double	Curve 3: The left curve shape parameter.
TemperatureCurve4	double	Curve 4: The right curve shape parameter.
MoistureCurve1	double	Curve1: The optimum volumetric soil water content (in %) for growth.
MoistureCurve2	double	Curve2: The minimum volumetric soil water content where growth may occur.
MoistureCurve3	double	Curve3: the left curve shape parameter
MoistureCurve4	double	Curve4: 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	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. LeafBiomassTOLAI determines LAI as a function of leaf biomass. If MaximumLAI = 0.0, then only leaf biomass determines LAI and the growth limits.
KLAI	double	KLAI and MaximumLAI determine LAI as a function of wood biomass. The large wood mass (g C/m ²) at which half of theoretical maximum leaf area is achieved.
MaximumLAI	double	The theoretical maximum leaf area index for a cohort.
MinimumLAI	double	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.

WoodDecayRate	double	This parameter defines the maximum fraction of the species' dead wood that decomposes. Value: $0.0 \leq \text{number} \leq 1.0$. Unitless.
MonthlyWoodMortality	double	A monthly fraction of wood mortality, <i>constant through time and regardless of successional stage</i> . 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	Determines how quickly longevity-related mortality begins and operates as in Biomass Succession. Value: $5.0 \leq \text{decimal number} \leq 25.0$. 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.
FoliageDropMonth	integer	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: <i>Note that FoliageDropMonth=9 means that half the leaves will drop in October (one month offset) and the other half drop in November.</i>
CoarseRootFraction	double	The fraction of aboveground net primary productivity that is used to compute the ANPP of coarse roots. Units: fraction of ANPP (0.0 – 1.0).
FineRootFraction	double	The fraction of aboveground net primary productivity that is used to compute the ANPP of fine roots. Units: fraction of ANPP (0.0 – 1.0).

2.55 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.

2.55.1 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.

2.55.2 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.

2.55.3 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.

2.55.4 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.

2.55.5 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.

2.55.6 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.

2.56 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.

2.56.1 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.

2.56.2 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.

2.56.3 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.

2.56.4 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.

2.56.5 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 for each initial community. Each active site on the landscape is assigned an initial community. The initial community specifies the cohorts that are present including species, age, biomass (g m^{-2}), leaf biomass, and wood biomass.

Each initial community has an associated map code that corresponds to the accompanying map, as well as information about the cohorts present, including species, ages, biomass (g m^{-2}), woody biomass, and leaf biomass. Note: ANPP ($\text{g m}^{-2} \text{yr}^{-1}$) is initialized with a value of 0 and is assigned a value during the first time step.

7.1 FileName

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

7.2 CSV file 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 2.7). Value: $0 \leq \text{integer} \leq 65,535$. Each communities' map code must be unique. Map codes do not have to appear in any order, and do not need to be consecutive.

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).

WoodBiomass: Wood biomass must be entered as an integer (no significant digits).

LeafBiomass: Leaf biomass must be entered as an integer (no significant digits).

MineralNallocation, MineralNfraction, Nresorption: *You will notice a warning during initialization that these data are missing. This is intentional and you can ignore this warning.*

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).

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)
```