LANDIS-II
Forest Carbon Succession Extension
v1.0 release

User Guide

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1. Introduction

This document describes the Forest Carbon Succession v1.0 (ForCs) 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. It is compatible with v6 of the core.

The growth and reproduction generally follow the Biomass Succession (v2) extension and the methods outlined in Scheller and Mladenoff (2004). The ForCs calculates how cohorts reproduce, age, and die. In addition, changes in cohort biomass (g C /m^2), dead organic matter (DOM) and soil carbon are tracked over time. The modelling of decay generally follows the methods outlined in Kurz et al. (2009).

1.1. Carbon Pools

ForCs tracks biomass in two live biomass pools and several dead organic matter (DOM) and soil pools (Table 1). Other pools are calculated each time step as needed.

The live carbon pools are broken into a woody pool, which is 90% of the aboveground biomass, and a foliage pool which is the remaining 10% of the aboveground biomass (Niklas and Enquist 2002). When material is transferred into the DOM and soil pools (e.g., through cohort death or turnover), the Woody pool is further divided into Merchantable wood and Other woody material. The merchantable portion is calculated as:

$$\text{PropStem} = a\,(1 - b^{Age}) \qquad \text{Eq 1.}$$

The parameters A and B are specified by the user in the input file. The merchantable portion of the stem is transferred to the Snag stemwood pool and the remainder to the Snag other wood pool; each can have a unique decay rate.

The C in roots is also calculated, as needed, from the aboveground biomass. First, the total root biomass is calculated using a user-defined root:shoot ratio that can vary depending on the total aboveground biomass. The fine roots are calculated as another user-defined proportion of the total root biomass. Coarse roots are simply calculated as the difference between the total root biomass and the fine root biomass.

Each of the DOM and soil pools (shown in Table 1) is tracked for each site, and for each species that is present, or has ever been present, on each site.

1.2. Initializing Carbon Pools

At the beginning of a scenario, the initial communities begin with appropriate living and dead biomass values estimated for each site. However, the user does not supply the initial biomass estimates. Rather, the ForCs extension iterates the number of time steps equal to the maximum cohort age for each site.

Beginning at time (t - oldest cohort age), cohorts are added at each time step corresponding to the time when the existing cohorts were established. Thus, each cohort undergoes growth and mortality for the number of years equal to its current age, and its initial biomass value reflects competition among cohorts. *Note: this is a computationally intensive process that may require significant time for complex initial landscapes.*

Table 1. The carbon pools tracked in ForCs and available as outputs.

Pools and sub-pools	Stored in memory	Description
1. Aboveground Biomass[1]	Yes	Living, aboveground biomass for each species and age-cohort on a site.
1.1. Woody[2]	Generated	90% of aboveground biomass.
1.1.1. Merchantable[3]	Generated	Live stemwood of merchantable size. User defined percent of woody biomass.
1.1.2. Other woody[3]	Generated	Live branches, stumps and small trees. User defined percent of woody biomass.
1.2. Leaves[2]	Generated	10% of aboveground biomass.
1.3. Fine roots	Generated	User defined root: shoot ratio.
1.4. Coarse roots	Generated	User defined root: shoot ratio.
2. Dead organic matter	Generated	Dead wood, litter and forest floor organic matter
2.1. Snag stem[3]	Yes	Dead standing stemwood of merchantable size.
2.2. Snag other wood[3]	Yes	Dead branches, stumps and small trees.
2.3. Medium[3]	Yes	Coarse woody debris on the ground. It may be on the surface or buried within the forest floor.
2.4. Aboveground very fast[3]	Yes	The L horizon comprised of foliar litter plus dead fine roots, approximately <5mm diameter.[4]
2.5. Aboveground fast[3]	Yes	Fine and small woody debris plus dead coarse roots in the forest floor, approximately ≥5 and <75mm. diameter.
2.6. Aboveground slow[3]	Yes	F, H and O horizons.[4]
2.7. Belowground fast[3]	Yes	Dead coarse roots in the mineral soil, approximately ≥5 diameter. (This pool is not considered part of the soil because it is typically missed or removed from field sampling, C. Shaw, pers. comm.)
3. Soil	Generated	Mineral soil.
3.1. Belowground very fast[3]	Yes	Dead fine roots in the mineral soil, approximately <5mm diameter.
3.2. Belowground slow[3]	Yes	Humified organic matter in the mineral soil.
4. Undefined		
4.1. Extra pool	Yes	A decaying pool written into the code but with no inputs unless added by the user.

In contrast to the living pools, users are required to provide initial estimates of DOM and soil carbon (g C /m^2) for the start of the spin-up procedure (t - oldest cohort age). These values should roughly correspond to

[1] Scheller and Mladenoff (2004)
[2] Source: Originally in Biomass v2.1 code, proportions modified based on Niklas and Enquist (2002)
[3] Based on Kurz et al. (2009)
[4] Soil Classification Working Group (1998).

stocks when cohort age is zero. Default values are 0 g C /m^2 which will likely result in an underestimate of initial carbon stocks. During the initialization of the biomass values, material will be added to, and decayed from the soil pools. Thus, the soil C values at year 0 will likely be different from those entered by the user.

There are two methods by which these initial DOM and soil values can be determined. One is to use field data, if they are available. Another is to do a separate run of the model for only a single time step.

In an initialization run, set the spin-up soils flag in the input file to "true", set the scenario to 1 time step, and use an initial conditions file that has only the maximum ages or fire return interval of each species in each ecoregion. The model will then run a special soil spin-up initialization phase. This phase operates by growing the biomass pools to the largest age present on the site as defined in the initial conditions file. At this age, the model will then assume that **all cohorts present have been killed by a high severity (severity = 4) fire, and then will regrow exactly as before. This process will repeat until the slow soil pools have stabilized, which is defined as the size of the slow soil pool at the end of one cycle is the same (to a user-specified tolerance) as the slow soil pool at the end of the next cycle.** The model will output the size of the soil pools by species and ecoregion at the end of time step 1. These soil pools can then be used to populate the initial estimates of DOM and soil carbon for a standard model run.

The advantage of using the built-in spin-up function is that it will minimize the initialization artefact from the DOM and soil pools, which can be substantial. The disadvantages are that it requires a separate run of the model, and that it could take some time depending on the number of species and ecoregions in the landscape. Note that since the purpose of this run is to get reasonable initial values by species and ecoregion, one can use a smaller, simpler landscape for determining the initial values than is needed to do a full simulation.

This overall initialization process (both biomass and soils) does not account for disturbances that would likely happen prior to initialization and therefore overestimates initial live biomass and underestimates initial dead biomass quantities.

Note: *An initial (time zero) ANPP and climate stream are required for initialization (see below).*

1.3. Cohort Reproduction - Shade Calculation

In order for a species to seed a site or to resprout on a site, there must be sufficient light. Sufficient light is determined by comparing the species' shade tolerance with the shade on the site.

There are six possible site shade classes ranging from zero (no shade) to 5 (highest shade). Site shade is calculated based on the ratio between the biomass present on a site and the maximum possible biomass on a site. A site will remain shade class 0 until the minimum biomass for shade class 1 is reached. The maximum possible biomass varies by ecoregion.

1.4. Cohort Reproduction – Seeding

In this form of reproduction, a species reproduces from seeds. Each species has an effective and maximum seeding distance. LANDIS-II calculates the probability of a seed landing at a site using "WardSeedDispersal", "NoDispersal" or "UniversalDispersal" algorithms. These algorithms are described in section 4.5.1 Seeding of the LANDIS-II Conceptual Model Description and the Technical Report: LANDIS-II double exponential seed dispersal algorithm.

To determine if a species that has reproduced on a site establishes itself, the species' probability of establishment (P_{EST}) is compared with a uniform random number between 0 and 1.

1.5. Cohort Reproduction – Disturbance Interactions

Every disturbance will trigger succession at each site at the time step that the disturbance(s) occur. In succession, there is a hierarchy of reproduction options following a disturbance that gives reproductive precedence to species with propagules available on site.

If planting (currently possible only through a Harvest extension) is triggered for one or more species, then no other reproduction will occur. Planting is given highest precedence as we assume that a viable cohort is generated. However, the probability of establishment must be greater than zero.

If serotiny (only possible immediately following a fire) is triggered for one or more species, then neither resprouting nor seeding will occur. Serotiny is given precedence over resprouting as it typically has a higher threshold for success than resprouting. This slightly favours serotinous species when mixed with species able to resprout following a fire.

If resprouting (which can be induced by many disturbance types) is triggered, then seeding will not occur. Finally, if neither planting, serotiny, nor resprouting occurred, seeding dispersal into a site will occur.

1.6. Cohort Growth, Ageing, and Litterfall

1.6.1. Cohort Growth and Ageing

Growth and ageing follow the algorithms in the Biomass Succession Extension v2.1 with the exception that units are g /m^2/yr and maximum biomass is read from the input file.

Cohort reproduction is the establishment of a cohort, aged 1 year and the calculation of its initial biomass.

$$B_{AGE=1\_SPP} = 0.025 \times B_{MAX\_S\_E} \times e\ (-1.6 \times B_{ACT}/B_{MAX\_ECO}) \qquad \text{Eq 2.}$$

where $B_{MAX\_S\_E}$ is the maximum aboveground biomass possible for the species in the ecoregion; $B_{MAX\text{-}ECO}$ is the maximum aboveground biomass possible for the ecoregion; and B_{ACT} is the current total aboveground biomass for the site (not including other new cohorts). Initial biomass must be ≥ 1 (g / m2); if < 1, initial biomass is set equal to 1. Note: this initial cohort will be grouped ('binned') appropriately into a larger cohort (e.g., 1 – 10) at the next successional time step.

Cohort aboveground net growth is based on the principles outlined in Scheller and Mladenoff (2004). Cohort net growth takes into consideration the maximum ANPP, the age of the cohort, species, ecoregion, competition and maximum biomass possible. Cohort aboveground net growth is gross growth minus development-related mortality.

Cohort ageing is simply the addition of the time step to each existing cohort.

As a cohort nears its longevity age, there will be an increase in the loss of biomass. This is called age-related mortality, and the age at which this mortality begins to be a factor is species-specific and controlled by the user. The biomass will decline to near zero at the maximum life span. Cohorts are not randomly killed as in Age-Only Succession. If a cohort exceeds the longevity for that species, then the cohort dies.

1.6.2. Litterfall

ForCs captures biomass from turnover (e.g., leaf litter) and age-related mortality and adds these to the appropriate DOM pool. With the exceptions noted in the table below, the user has no control over rates of input or which DOM or soil pool receives the biomass input.

Table 2. Paths of carbon transferred from biomass pools to dead organic matter (DOM) and soil pools.

From Biomass Pool	To DOM and Soil pools	Proportion of biomass into each DOM or soil pool
Leaves	Aboveground very fast	1.0
Fine roots	Aboveground & Belowground very fast	User input
Coarse roots	Belowground fast & Aboveground fast	User input
Merchantable	Snag stems	1.0
Other woody	Aboveground fast & Snag other	User input

Litterfall and turnover are calculated from the predicted mortality for the year and the predicted ANPP. First, the leaf turnover is calculated as:

$$LeafTurnover = actualANPP * leafFraction * 0.8 \qquad \text{Eq 3.}$$

Leaf fraction is a constant 35%. In young stands, the amount of biomass mortality predicted by this leaf turnover is greater than the total amount of biomass mortality predicted for the cohort, so it becomes the only input to the DOM pools. In older stands, the remaining mortality is divided between the woody and non-woody pools:

$$Mortnonwood = Mortpred * ((LeafTurnover * LeafLongevity) - LeafTurnover) / Biocohort) \qquad \text{Eq 4.}$$

Root turnover and mortality are calculated two different ways. Root turnover is the determined based on a user-defined proportion that is applied to the root values. This proportion can be different for coarse and fine roots, and can also vary based on the amount of aboveground biomass. Root turnover is calculated every year. Other root mortality is calculated only when the amount of aboveground biomass in the cohort is decreasing. The model calculates the amount by which the total roots decreased and apportions this amount between the coarse and fine roots according to the proportion of each that were present prior to the biomass decline. These amounts are then transferred to the DOM pools. Note that the actual *amount* of roots is still being calculated based on the aboveground biomass.

Note that because the methods of calculating the amount of total, coarse or fine roots can vary based on the aboveground biomass, some discontinuities can occur. For example, even though total biomass is decreasing, and total root biomass is decreasing, either fine roots or coarse roots may increase. If this occurs, a warning message will be written to the log file. The methods to calculated root mortality ensure that the appropriate amount of biomass is transferred to the biomass pools.

1.7. Dead Organic Matter and Soil C Decay

When a cohort dies and is not consumed by a mortality agent (e.g., fire or harvest), its biomass carbon is added to the dead organic matter and soil pools. The proportion of biomass carbon transferred to different dead pools is partially under user control.

Decomposition for each DOM and soil pool is modelled using a temperature-dependent decay rate. The user defines base decay rates, Q_{10} parameters and mean annual temperatures (derived from monthly minimum and maximum temperatures). Once the amount of carbon to be decayed is determined, a user-defined proportion of it is released as gas and the remainder is transferred to the more stable slower pools. The slow pools release all of their decayed material to the atmosphere. Decay dynamics are simulated in each year. These algorithms are described in equations 5 & 6 and in Kurz et al. (2009).

In addition, physical transfers are simulated between DOM and soil pools. Dead trees drop branches and fall over time; carbon is moved from the forest floor into the mineral soil. These are also simulated on an annual basis. The transfer rates are under user control.

Applied decay rates (a_k) are calculated for each DOM and soil pool (k) from the Base decay rate (B_k)

$$a_k = B_k \times \text{TempMod} \qquad \text{Eq. 5}$$

Where

$$\text{TempMod} = e^{((\text{MAT}-10)\times\ln(\text{Q10})\times 0.1)} \qquad \text{Eq. 6}$$

The MAT is the mean annual temperature of the ecoregion, 10 is the reference mean annual temperature of 10 ◦C, and Q10 is a temperature coefficient.

1.8. Interactions with Disturbance Extensions

Disturbances can alter the dead organic matter and soil pools. They can add carbon (e.g., wind) and/or remove carbon (e.g., fire will add some woody C and remove litter).

ForCs was written to allow disturbances to interact with the DOM and soil pools. Currently, a user is able to run the extensions: Base Fire, Base Wind, Base Harvest, Biological Disturbance Agents, and Dynamic Fuels and Fire with the ForCs v1.0. The Biomass Harvest extension, however, is not compatible with the ForCs. Tables allow the user to indicate: a) how the live biomass is transferred to their respective dead pools after being killed by a disturbance agent and b) whether and how much of the live or dead carbon pools leave the ecosystem to the air (as a gas) or to the forest products sector.

For example, if a fire kills a cohort, we would expect that all of its leaves and some of the woody biomass to be volatilized immediately and this biomass would not enter a dead organic matter or soil pool. In addition, we would expect some of the existing Snag stem pool to be volatilized during a fire and the rest to fall down, becoming part of the Medium pool.

This interface does not allow dynamic changes in the transfer rates into and out of the dead pools after a disturbance. The same transfer rates are used in all years, and can only vary by disturbance agent.

Special notes about how ForCs interacts with some of the extensions:

Base Fire and Dynamic Fire Extension

ForCs calculates the impacts of fire based upon the Fire Severity Index set by the Fire Extensions. Note that ForCs does not recognize fire severity variables of 0. This means if you simulate low intensity surface fires or grass fires with a Fire Extension, ForCs will not capture the impacts of that fire on DOM or soil C.

Note that a Fire Severity Index of 0 in the extension means different things when you are dealing with Base Fire or Dynamic Fire. In Base Fire, sites that are checked but do not have enough fuel to burn are logged with severity of 0 (R. Scheller, pers. comm.). In Dynamic Fire, if a fire burned a cell, but no cohorts died, then the severity class would be listed as 0 and the cell would be recorded as burned (used in area burned estimates, etc.) (B. Miranda, pers. comm.).

Base Harvest

If you wish to track C that is harvested you must request in the input file that some portion of C goes to the Forest Product Sector after harvest. This will record the amount of C removed from the ecosystem. The output can be used for checking on the mass-balance or sending the information to a wood-product model.

1.9. References

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2. Succession Input File

Nearly all the input parameters for this extension are specified in one main input file. 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.

2.1. Header

LandisData This parameter's value must be "ForC Succession".

Timestep This parameter is the timestep of the extension. Value: 1. Units: years.

2.2. SeedingAlgorithm

This parameter is the seeding algorithm to be used. Valid values are "WardSeedDispersal", "NoDispersal" or "UniversalDispersal". The algorithms are described in Section 4.5.1 Seeding of the LANDIS-II Conceptual Model Description and the Technical Report: LANDIS-II double exponential seed dispersal algorithm.

2.3. ClimateFile

The next row must contain the words "ClimateFile" and then the name of a file with climate information. Note that ForCs only uses this information to calculate mean annual temperature (MAT). This file format is used to maintain consistency with other extensions.

We recommend you input the desired MAT for each month and set the standard deviation to zero. Decomposition, as modelled in ForCs is highly sensitive to MAT and allowing inter-annual variability in MAT produced unrealistically high variability in Rh.

The inputs must include data for every ecoregion at time zero. Subsequent to time zero, one or many ecoregions can have their climate data updated at any chosen time step.

Mean Annual Temperature is calculated as:
MAT = [Sum of (Monthly mean temperature * days of Month)] / days in year

Where:
Monthly mean temperature = (AvgMin + AvgMax) / 2 + StdDev
StdDev = StdDevTemp * uniform random number between 1.0 and 2.0

2.4. Initial Communities

InitialCommunities This parameter is the file with the definitions of the initial communities at the active sites on the landscape
InitialCommunitiesMap 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

2.5. Output Table

The output table contains the information about how frequently the four different output files should be printed. All files give results by cell, and three also give the results by species and/or cohort. If a complex landscape is used, these files can become quite large. All output is printed at the end of the annual timestep. Thus, pools at t1 + fluxes at t2 = pools at t2.

First Row – ForCsOutput

Col 1: Interval for the biomass output table (years)

Col 2: Interval for the DOM & soil pools table (years)

Col 3: Interval for the Flux table (years)

Col 4: Interval for the Summary output table (years)

2.6. Soil Spin-up Controls

This table contains the information about whether to do the initial soil spin-up phase. It also sets the stopping rules.

First Row – SoilSpinUp

Col 1: On/Off Flag. 0 = off (do not do the spin up), 1 = on

Col 2: Tolerance. (Percentage > 0 and <=100).

> This is the amount by which the slow soil pools can vary from one year to another. Smaller values mean that there is little change between the pool sizes.

Col 3: Maximum number of iterations. (Integer > 0)

> This value tells the model the maximum number of cycles to use for calculating the soil values. It will only be used if, for some reason, the change in soil values from one cycle to the next continues to be larger than the percentage set in Col 2. This is a necessary value so that the model can stop, even without convergence.

2.7. AvailableLightBiomass Table

This table contains the minimum relative biomass for shade classes 1 - 5.

The first row in the table is a list of all the active ecoregions defined in the ecoregions input file (see Chapter 6 in the LANDIS-II Model User's Guide). The ecoregions can appear in any order; they do not need to appear in the same order as in the ecoregions input file.

First Row – Ecoregions

The remaining rows give the shade class and the minimum biomass percentage for each ecoregion.

Col 1: Shade Class

> This column contains shade 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 shade class 0 (no shade) until the minimum relative biomass for shade class 1 is reached. Likewise, if relative biomass is between the amount defined for classes 1 and 2, the site is given an shade class of 1. And so on up to class 5.

Col 2- Minimum Biomass Percentage per Ecoregion

> Each ecoregion listed in the table's first row must have a separate column of minimum biomass by shade class. The percentages represent the lower threshold of biomass on a site relative to the ecoregion's maximum possible biomass (for any species) for the site to enter the shade class indicated in column 1. Sites with less than the lowest threshold value will be assigned to shade class 0 (full sunlight).
>
> Value: 0.0 ≤ decimal number ≤ 100.0. Units: percent.

2.8. LightEstablishmentTable

Beginning with Biomass Succession (v2), the optional table SufficientLight was added, now named LightEstablishmentTable. The table allows a more nuanced 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.

Col 1: Species Shade Tolerance Class

This column contains shade class values. The shade classes must be in increasing order: class 1 first and ending with class 5. Shade class 5 represents the most shade tolerant.

Valid values: integers from 1-5.

Cols 2-7: 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.

2.9. SpeciesParameters

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

Col 1: Species The species must be defined in the species input file (see Chapter 5 in the LANDIS-II Model User Guide). Species may appear in any order.

Col 2: Leaf Longevity This parameter is the average longevity of a leaf or needle. Value: 1.0 ≤ decimal number ≤ 10.0. Units: years.

Col 3: Mortality Curve Shape Parameter

This parameter determines how quickly age-related mortality begins. Value: 0.0 ≤ decimal number ≤ 50.0. If the parameter = 5, then age-related mortality will begin at 10% of life span. If the parameter = 15, then age-related mortality will begin at 70% of life span. Note that if the value is 0, mortality will be 100% for all ages.

Cols 4: Minimum age for merchantable stems

When the age of the cohort is greater than the minimum age, an equation (see below) is used to determine the proportion of the biomass "woody" pool that is merchantable and therefore should go to the snag stem pool when killed or to the forest products sector if harvested. The remainder goes to the snag other pool or the above ground fast pool (see col. 8).

Cols 5-6: Merchantability curve shape parameters a and b

These columns define the parameters used to determine proportion of the biomass Woody pool that is merchantable, where x is the age and PropStem is the proportion which varies between 0 and 1.

$$PropStem = a * (1 - b^{x})$$

Col 8: Other wood to soil

This column gives the proportion of the Other wood biomass C (as determined from the parameters in cols 5-7) that when killed goes into the Aboveground fast pool rather than the Snag other pool.

Valid values: 0.0 ≤ decimal number ≤ 1.0

2.10. AgeOnlyDisturbances table

This table is needed by the code, but the values in the input file are superseded by later tables in this main input file. The input is only one line that contains the words "AgeOnlyDisturbances:BiomassParameters" followed by a file name of an existing file. This requirement will be removed in future updates.

2.11. DOMPools table

This is the first of three sets of parameters controlling decay rates and stocks of DOM and soil pools. Note that all DOM and soil processing is handled in units of carbon: g C/m^2/yr.

Col 1: ID row headings. These are the pool IDs used internally by ForCs. They must be numbered 1-10 and cannot be altered by users. They are in this table for reference for other tables.

Col 2: Name of each of the DOM and soil pool. These too are fixed and are there for reference purposes.

Col 3: Proportion of the decayed material that goes to the atmosphere. Range: 0-1.

2.12. EcoSppDOMParameters

The base decay rate (before using the Q_{10}), initial stocks, and Q_{10} for all combinations of ecoregion, species and DOM and soil pool.

Col 1: Ecoregions. This must be an ecoregion as defined in the ecoregions input file.

Col 2: Species. This must be a species as defined in the species input file.

Col 3: DOM or soil Pool. This must be a value from 1 to 10, and refers to the pools given above.

Col 4: Base Decay Rate for the given ecoregion, species, and pool. Valid values: 0.0 ≤ decimal number ≤ 1.0. Note that a value of 0 will trigger a warning message as no decay will occur.

Col 5: Initial DOM & soil pool values to start the spin-up procedure. They should correspond to a cohort age 0. Units: g C/m2/yr. Default value 0 (not recommended unless using ForCs for initialization).

Col 6: Q_{10} value for a Reference Temperature of 10°C. Valid values: 1.0 ≤ decimal number ≤ 5.0

2.13. ForCsProportions

This table gives the proportion of physical turnover transferred from a biomass pool to a specific DOM/soil pool, or between certain DOM/soil pools. Users can change the proportions, but not where material is transferred from or to. Numbers in brackets are the DOM/soil pool IDs. Proportions are to be specified as a value between [0, 1].

Col 1: Fine Roots to Very Fast Aboveground (1): When roots die, the proportion of the killed fine root carbon pool going to the above ground very fast pool. The remainder goes to the below ground very fast pool (2).

Col 2: Coarse Roots to Fast Aboveground (3): When roots die, the proportion of the killed coarse root carbon going to the above ground fast pool. The remainder goes to the below ground fast pool (4).

Col 3: Slow Aboveground (6) to Slow Belowground (7): Annual proportion of C transferred between these two pools.

Col 4: Snag Stem (8) to Medium (5): Annual proportion of C transferred between the snag stem pool and the medium pool. This could represent a process such as snag stems falling or breaking.

Col 5: Snag Other (9) to Fast Aboveground (3): Annual proportion of C transferred between these two pools. This represents a process such as the dead branches falling from snags.

2.14. DisturbFireTransferDOM

There are a set of two tables that define how material is transferred out of different DOM or soil pools after a fire. This table determines the fire impacts on the DOM and soil pools. Zero is the default causes no transfers. We allow only certain transfers at this point. Users may affect the amount that is transferred, but cannot create a new path. The allowable transfers are from any pool to the air (i.e., as a gas), from snags to the ground (to DOM), and from stem snags to the Forest Product Sector.

This table is only for the transfers after fire. Note that the table must be present (even if it contains no values) even if the fire extension is not being used.

Col 1: Intensity or fire severity (1-5) from the Fire Extension.

Col 2: From DOM/soil pool, numbered 1-10.

Col 3: To Air. This is the proportion of the DOM or soil pool C stocks that is consumed by the fire and released to the air. Values 0-1.0.

Col 4: To DOM/soil. This is the proportion of the DOM pool C stocks that should be transferred to other DOM and soil pools. The only pathways that are operational are to go from the snag pools (8 and 9) to the ground. Thus, values in this column for any other pool will have no impact. Values 0-1.0.

Col 5: To FPS: This the proportion of the DOM pool C stocks that should be transferred to the forest product sector. This column could be used to simulate salvage harvesting of stems that were dead before the fire hit. Salvage harvesting of fire-killed trees is handled in the DisturbFireTransferBiomass table.

2.15. DisturbOtherTransferDOM

There are a set of two tables that define how a disturbance impacts different DOM or soil pools after a non-fire disturbance. We allow only certain transfers at this point. Users may affect the amount that is transferred, but cannot create a new path. The allowable transfers are from any pool to the air (i.e., as a gas), from snags to the ground (to DOM), and from stem snags to the Forest Product Sector.

This table is only for the transfers after disturbances other than fire. Note that the table name must be present even if the no other disturbance extensions are being used and even if it contains no values.

Col 1: Disturbance type. This must be lowercase disturbance names. Valid entries are: “harvest”, “wind”, and “bda”.

Col 2: From DOM/soil pool, Ids 1-10.

Col 3: To Air. This is the proportion of the DOM and soil pool C stocks that is consumed by the disturbance and released to the air. Values 0-1.0.

Col 4: To DOM. This is the proportion of the DOM pool C stocks that should be transferred to other DOM pools. The only pathways that are operational are to go from the snag pools (8 and 9) to the ground. Thus, values in this column for any other DOM pool will have no impact. Values 0-1.0.

Col 5: To FPS: This the proportion of the DOM pool C stocks that should be transferred to the forest product sector. A warning will be issued if the user tries to send a belowground DOM or soil pool to the forest product sector. This column could be used to simulate salvage harvesting of stems that were dead before the disturbance hit. Salvage harvesting of newly-killed trees is handled in the DisturbOtherTransferBiomass table. Values 0-1.0.

2.16. DisturbFireTransferBiomass

This transfers material from the biomass pools to the DOM, FPS, or air when it's killed by the fire extension. If there is mortality from a fire,as determined by the fire extension, but nothing in this table to tell the model what pools should receive the C then C will disappear and not be accounted for in the fluxes. You can't force the combustion of any biomass pools (e.g. foliage) with this table.

Note that the table must be present even if it contains no values and even if the fire extension is not being used.

Values should be entered for every combination of fire intensity and biomass pool, and these values should add up to 1. A missing row, or values sum to less than 1 will trigger a warning.

Col 1: Fire Intensity Valid values are 1-5, from the Fire Extension

Col 2: Biomass Pools. Indices to be used when referring to biomass pools are (note that 4 is not a valid value):

1. Merchantable part of the woody pool
2. Foliage
3. Other wood - non-merchantable part of the woody pool
5. Coarse Root
6. Fine Root

Col 3: To Air. This is the proportion of the given biomass pool C stocks that is consumed by the fire and released to the air. Values 0-1.0.

Col 4: To FPS: This the proportion of the given biomass pool C stocks that should be transferred to the forest product sector if killed by a fire.

Col 5: To DOM. This is the proportion of the given biomass pool C stocks that should be transferred to DOM and soil pools. Values 0-1.0.

2.17. DisturbOtherTransferBiomass

There are a set of two tables that define how material is transferred out of different biomass pools after a non-fire disturbance. This table tells the model how to transfer material from the biomass pools to the DOM, FPS, or air when it is killed by the disturbance extension.

The allowable transfers are from any pool to the air (i.e., as a gas after combusting in a land clearing fire), to the dead carbon pools, and to the Forest Product Sector.

This table is only for the transfers after a harvest, wind or biological disturbance agent event. Note that the table heading must be present even if it contains no values.

Values should be entered for every combination of disturbance type and biomass pool, and these values should add up to 1. If a row is missing, or if the values on a row sum to less than 1, then when the carbon that was in the biomass that was killed will not be accounted for; it will not be transferred to the DOM pools, or show up in the flux table as a transfer to air or the forest product sector.

Col 1: Disturbance type: Valid values are lowercase: harvest, wind, bda.

Col 2: Biomass Pools. Indices to be used when referring to biomass pools are (note that 4 is not a valid value):

1. Merchantable part of the woody pool
2. Foliage
3. Other wood - non-merchantable part of the woody pool
5. Coarse Root
6. Fine Root

Col 3: To Air. This is the proportion of the given biomass pool C stocks that is consumed by the disturbance and released to the air. Values 0-1.0.

Col 4: To FPS: This the proportion of the given biomass pool C stocks that should be transferred to the forest product sector.

Col 5: To DOM. This is the proportion of the given biomass pool C stocks that should be transferred to DOM pools. Values 0-1.0.

2.18. ANPPTimeSeries

The ANPP data is provided by species and ecoregion for year 0 and any other years. For each period, ANPP also has a standard deviation, allowing for variation within that time period. The model will use the standard deviation to pick a random number produced by a random number generator that assumes a normal distribution. The ANPP and standard deviation in the file will be used from the given year until a new set of values are provided. For example, if ANPP is provided in year 5 and in year 10, then the year 5 ANPP and standard deviation are applied for years 5-9.

ANPP can also be provided for years prior to year 0 using negative values for the year. These values will be used for the initialization phase.

Col 1: Year This is the first year for the period of time during which the model will apply the ANPP values. Year 0 must always be present. All other years are optional.

Col 2: Ecoregion This must correspond to an ecoregion in the ecoregions file.

Col 3: Species This must correspond to a species defined in the species input file.

Col 4: ANPP This parameter is the maximum possible aboveground net primary productivity (ANPP) for the species in the ecoregion during the time period. This parameter is independent of age and competition. Units: g/m2/yr.

Col 5: ANPP standard deviation

2.19. MaxBiomassTimeSeries

This table is almost identical in formation to the ANPP table, except that it is does not have a standard deviation column. Like the ANPP table, maximum biomass data is provided by species and ecoregion for year 0 and any other years. The maximum biomass in the file will be used from the given year until a new set of values are provided.

Maximum biomass can also be provided for years prior to year 0 using negative values for the year. These values will be used for the initialization phase.

Col 1: Year This is the first year for the period of time during which the model will apply the maximum biomass values. Year 0 must always be present. All other years are optional.

Col 2: Ecoregion This must correspond to an ecoregion in the ecoregions file.

Col 3: Species This must correspond to a species defined in the species input file.

Col 4: Maximum Biomass This parameter is the maximum possible maximum biomass for the species in the ecoregion during the time period. Units: g/m2.

2.20. EstablishmentProbabilities Table

The establishment probability parameter controls regeneration likelihood for different species and regions in different years. Values must be present and greater than 0 for a species to occur on a site (other than the cohorts defined initially). Like the ANPP and maximum biomass tables, establishment probabilities must be provided by species and ecoregion for year 0 and any other years. The establishment probability in the file will be used from the given year until a new set of values are provided.

Establishment probabilities can also be provided for years prior to year 0 using negative values for the year. These values will be used for the initialization phase.

Col 1: Year This is the first year for the period of time during which the model will apply the establishment probabilities. Year 0 must always be present. All other years are optional.

Col 2: Ecoregion This must correspond to an ecoregion in the ecoregions file.

Col 3: Species This must correspond to a species defined in the species input file.

Col 4: Probability The probability that a species establishes in the ecoregion. Value: $0.0 < \text{decimal number} \leq 1.0$.

2.21. RootDynamics Table

The root dynamics table contains the parameters that are used to define the amount of roots and their annual turnover for different species and region combinations. Note that fine roots are defined as less than or equal to 5mm diameter. All other roots are coarse roots.

Values may be entered that apply to different ranges of aboveground minimum biomass. The model insists that at least one set of parameters that applies to a minimum aboveground biomass of 0 is entered for each ecoregion-species combination. Also, it assumes that the values are entered in ascending order of minimum biomass. For example, values that apply to a minimum biomass of 0 must be entered before those that apply starting at minimum biomass of 3000, which must be entered before those that apply to a minimum biomass of 6000. The model does not check that this order occurred.

Col 1: Ecoregion This must correspond to an ecoregion in the ecoregions file.
Col 2: Species This must correspond to a species in the species input file.
Col 3: MinABio: The minimum amount of aboveground biomass for which the defined parameters apply. Units: g/m^2 Value: ≥ 0.0
Col 4: Ratio The proportion of aboveground biomass that is used to estimate total root biomass. Value: $0 < \text{decimal number} \leq 1.0$
Col 5: Prop Fine Roots: The proportion of root biomass that are fine roots. All other roots will be coarse roots. Value: $0 < \text{decimal number} \leq 1.0$
Col 6: Fine Root turnover The proportion of fine root biomass which dies annually and will be added to the DOM
Col 7: Coarse Root turnover The proportion of coarse root biomass which dies annually and will be added to the DOM

3. Example Main Input File

```
LandisData  "ForC Succession"

Timestep  1

SeedingAlgorithm  WardSeedDispersal

ClimateFile      "ClimateInputsv2.txt"

InitialCommunities      "./initial-communities3.txt"
InitialCommunitiesMap   "./initial-communities.gis"


ForCSOutput
>> Output interval
>>  Biomass     DOM Pools   Flux       Summary
>>  -------     ---------   ----       -------
    1           1           1          1

SoilSpinUp
>>On/Off     Tolerance   Max
>>Flag         %         Iterations
>>-------    ---------   -------
   0          1.0          10

AvailableLightBiomass
>>Shade
>>Class  Ecoregions
>>------------------------------------------------

  eco1   eco2
1 30%    30%
2 35%    35%
3 55%    55%
4 80%    80%
5 100%   100%


LightEstablishmentTable
>> Spp Shade    Probability
>> Class by Actual Shade
>> ---------------------------------
>>       0      1      2      3      4      5
  1      0.5    0.0    0.0    0.0    0.0    0.0
  2      0.5    0.5    0.0    0.0    0.0    0.0
  3      0.2    0.2    0.5    0.0    0.0    0.0
  4      0.1    0.1    0.2    0.5    0.0    0.0
  5      0.1    0.5    0.2    0.2    0.5    0.5


SpeciesParameters

>> Species  Leaf   Mortal   Merchantable    Merch.      Merch.      Prop.
>>          Long   Shape                  Curve Shape Curve Shape   Other wood
>>                  Param   Min Age         Param a     Param b     to FastAG
>> -------  ----   ------      ------------    ----------- ----------- ----------
   pinubank 3.0      10         5              0.7546  0.983          0.25
   querelli 1.0      10         5              0.7546  0.983          0.25


AgeOnlyDisturbances:BiomassParameters  "AgeOnlyDistur.txt"

DOMPools
>>  ID      Name                         Prop to
>>                                       Atm
>>  ----    ------------------------     ---------
    1       "Very Fast Aboveground"      0.815
    2       "Very Fast Belowground"      0.83
    3       "Fast Aboveground"           0.83
    4       "Fast Belowground"           0.83
    5       "Medium"                     0.83
    6       "Slow Aboveground"           1
```

```
    7       "Slow Belowground"          1
    8       "Stem Snag"                 0.83
    9       "Other Snag"                0.83
    10      "Extra pool"                0.83

EcoSppDOMParameters
>> Max applied decay rate = 1    Min applied decay rate = 0
>> Warning if calculated applied decay rate is neg and set to 0 or >1 and set to 1.
>>
>>  Ecoregion   Spp         DOM/Soil Decay       Amount       Q10 RefTemp 10C
>>                          Pool     Rate        at T0
>>  ----------------------------------------------------------
eco1            pinubank       1      0.355   1.038          2.65
eco1            pinubank       2      0.5     0.016          2
eco1            pinubank       3      0.1435  13.455         2
eco1            pinubank       4      0.0374  100.316        2
eco1            pinubank       5      0.015   1250.047       2
eco1            pinubank       6      0.0033  1679.221       2.65
eco1            pinubank       7      0.0187  1657.338       2
eco1            pinubank       8      0.07175 47.481         2
eco1            pinubank       9      0.07    1.407          2
eco1            pinubank       10     0       0              2
eco2            pinubank       1      0.355   1.038          2.65
eco2            pinubank       2      0.5     0.016          2
eco2            pinubank       3      0.1435  13.455         2
eco2            pinubank       4      0.0374  100.316        2
eco2            pinubank       5      0.015   1250.047       2
eco2            pinubank       6      0.0033  1679.221       2.65
eco2            pinubank       7      0.0187  1657.338       2
eco2            pinubank       8      0.07175 47.481         2
eco2            pinubank       9      0.07    1.407          2
eco2            pinubank       10     0       0              2
eco1            querelli       1      0.355   0.458          2.65
eco1            querelli       2      0.5     0.028          2
eco1            querelli       3      0.1435  0.762          2
eco1            querelli       4      0.0374  40.912         2
eco1            querelli       5      0.015   1469.552       2
eco1            querelli       6      0.0033  1798.168       2.65
eco1            querelli       7      0.0187  2266.52        2
eco1            querelli       8      0.07175 5.312          2
eco1            querelli       9      0.07    0.429          2
eco1            querelli       10     0       0              2
eco2            querelli       1      0.355   0.458          2.65
eco2            querelli       2      0.5     0.028          2
eco2            querelli       3      0.1435  0.762          2
eco2            querelli       4      0.0374  40.912         2
eco2            querelli       5      0.015   1469.552       2
eco2            querelli       6      0.0033  1798.168       2.65
eco2            querelli       7      0.0187  2266.52        2
eco2            querelli       8      0.07175 5.312          2
eco2            querelli       9      0.07    0.429          2
eco2            querelli       10     0       0              2



ForCSProportions
>> Proportion of physical turnover transferred from a biomass pool to a specific DOM or soil pool.
>> Proportions are to be specified as a value between [0, 1].
>>
>> Biomass Fine Roots: When roots die, the proportion of the killed fine root carbon pool going to the
above ground very fast pool (i.e. DOMPoolID = 1, "Very Fast Aboveground")
>> where the remainder going to the below ground very fast pool (i.e. DOMPoolID = 2, "Very Fast
Belowground").
>>
>> Biomass Coarse Roots: When roots die, the proportion of the killed coarse roots going to the above
ground fast pool (i.e. DOMPoolID = 3, "Fast Aboveground")
>> where the remainder going to the below ground fast pool (i.e. DOMPoolID = 4, "Fast Belowground").
>>
>> DOM SlowAG (6) to SlowBG (7): Proportion of C transferred between these two pools annually.
>>
>> DOM StemSnag (8) to Medium (5): Proportion of C transferred between these two pools annually.
>>
>> DOM BranchSnag (9) to FastAG (3): Proportion of C transferred between these two pools annually.
>>
>>
```

```
>>  Biomass Biomass     DOM         DOM             DOM
>>  Fine    Coarse      SlowAG to   StemSnag to     BranchSnag
>>                      SlowBG      Medium          to FastAG
>>  ------- -------     ---------   -----------     ----------
    0.5     0.6         0.01           0.032           0.1

DisturbFireTransferDOM
>> This table determines the fire impacts on the DOM and soil pools. Zero and the default is no
transfers.
>> We allow only certain transfers at this point.
>> From any pool to Gas, from aboveground pools and snags to FPS, and from snags to the ground
>> (stem to medium or other to fast above)
>> No other transfers are allowed.

>>  Intensity   From     To    To       To
>>              DOM/Soil Air   DOM/soil FPS
>>  ----------------------------------------
    1           1       0.5     0.0     0.0
    1           3       0.2     0.0     0.0
    2           1       0.5     0.0     0.0
    2           2       0.25    0.0     0.0
    2           3       0.35    0.0     0.0
    2           8       0.0     0.4     0.0
    2           9       0.0     1.0     0.0
    3           1       0.65    0.0     0.0
    3           2       0.35    0.0     0.0
    3           3       0.4     0.2     0.0
    3           8       0.0     0.6     0.0
    3           9       0.2     0.4     0.0
    4           1       1.0     0.0     0.0
    4           2       0.5     0.0     0.0
    4           3       0.4     0.0     0.0
    4           5       0.1     0.0     0.0
    4           8       0.0     0.4     0.4
    4           9       0.3     0.5     0.0
    5           1       1.0     0.0     0.0
    5           2       0.65    0.0     0.0
    5           3       0.45    0.0     0.0
    5           5       0.1     0.0     0.0
    5           8       0.0     1      0.0
    5           9       0.5     0.5     0.0

DisturbOtherTransferDOM
>> We allow only certain transfers at this point.
>> From any pool to Gas, from aboveground pools and snags to FPS, and from snags to the ground
>> (stem to medium or other to fast above)
>> No other transfers are allowed.
>> Default is no transfer
>>  Disturbance     From    To      To         To
>>  Type            DOM     Air     DOM/soil   FPS
>>  ------------------------------------------------
    harvest         1       0.0     0.3        0.0
    harvest         8       0.0     0.4        0.6
    harvest         9       0.0     1          0.0
    wind            8       0.0     0.8        0.0
    wind            9       0.0     1.0        0.0

>> Biomass Pools
>> Indices to be used when referring to biomass pools
>> 1. Merchantable wood
>> 2. Foliage
>> 3. Other wood
>> 5. Coarse Root
>> 6. Fine Root

DisturbFireTransferBiomass
>> This transfers material from the biomass pools to the DOM, FPS, or air when it's killed by the fire
extension.
>> If there is mortality from a fire,as determined by the fire extension, but nothing in this table
>> to tell the model what pools should receive the C then C will disappear and not be accounted for in
the fluxes.
>> You can't force the combustion of any biomass pools (e.g. foliage) with this table.

>> Inten  From        To      To      To
>>   sity Biomass     Air     FPS     DOM/soil
>>  ------------------------------------------
```

```
  1      1            0      0      1
  1      2            0.5    0      0.5
  1      3            0      0      1
  1      5            0      0      1
  1      6            0      0      1
  2      1            0      0      1
  2      2            0.7    0      0.3
  2      3            0.1    0      0.9
  2      5            0      0      1
  2      6            0      0      1
  3      1            0      0.5    0.5
  3      2            0.75   0      0.25
  3      3            0.1    0      0.9
  3      5            0      0      1
  3      6            0      0      1
  4      1            0      0.5    0.5
  4      2            1      0      0
  4      3            0.1    0      0.9
  4      5            0      0      1
  4      6            0      0      1
  5      1            0      0      1
  5      2            1      0      0
  5      3            0.1    0      0.9
  5      5            0      0      1
  5      6            0      0      1


DisturbOtherTransferBiomass
>> This transfers material from the biomass pools to the DOM, FPS, or air when it is killed by the disturbance extension.
>> Default is no transfer, but then C will disappear and not accounted for in the fluxes.
>>  Disturbance     From        To      To      To
>>  Type            Biomass     Air     FPS     DOM/soil
>>  -----------     -------     ----    -----   -----
    harvest         1           0       0.8      0.2
    harvest         2           0       0        1
    harvest         3           0       0.2       0.8
    harvest        5           0        0       1
    harvest        6           0       0      1
    wind            1           0      0       1
    wind            2           0      0       1
    wind            3           0      0       1
    wind           5           0       0      1
    wind           6           0       0      1
    bda             1           0      0       1
    bda             2           0.3    0       0.7
    bda             3           0.2    0       0.8
    bda            5           0       0      1
    bda            6           0       0      1

ANPPTimeSeries
>> ANPP
>>  Yr   Eco   Spp          ANPP(g/m2/yr)   ANPP-Std
>> --------------------------------------------------------------
  0      eco1   pinubank       648    0
  0      eco1   querelli       1015   0
  0      eco2   pinubank       648    0
  0      eco2   querelli       1015   0

MaxBiomassTimeSeries
>>  Yr   Eco   Spp       MaxBiomass(g/m2)
>> ----------------------------------------
  0      eco1   pinubank       7128
  0      eco1   querelli       11165
  0      eco2   pinubank       7128
  0      eco2   querelli       11165


EstablishProbabilities
>>  Yr   Ecoregion   Spp         Prob
>> ------------------------ ---------------
  0      eco1   pinubank       0.01
  0      eco1   querelli       0.01
  0      eco2   pinubank       0.01
  0      eco2   querelli       0.01
```

```
RootDynamics
>> Eco   Species        MinB(g/m2)     Root:Shoot     PropFineRt     FRturnover     CRturnover
>> ------------------------ ------------------------------------------------------------------
  eco1   pinubank       0              0.399          0.18           0.6            0.01
  eco1   querelli       0              0.392          0.18           1              0.01
  eco1   querelli       5000           0.403          0.15           0.6            0.01
  eco2   pinubank       0              0.399          0.18           0.6            0.01
  eco2   querelli       0              0.392          0.18           1              0.01
  eco2   querelli       5000           0.403          0.15           0.6            0.01
```

4. Output

ForCs automatically produces output at the intervals specified in the ForCsOutput table. Comma-separated-value files are used rather than raster files due to the original 8-bit constraint in LANDIS-II and the potential for large file sizes.

4.1. ForCs-ANPP-Establishment-log.csv

This table reports internal values for error checking.

Col 1: Timestep

Col 2: Ecoregion

Col 3: Species

Col 4: MaxANPP. The ANPP drawn from the distribution prior to taking into account age, competition, etc.

Col 5: MaxBiomass. Should be the same as provided in the input file

Col 6: MAT. The calculated mean annual temperature

Col 7: ProbEst. The probability of establishment. Should be the same as provided in the input file.

4.2. log_Summary.csv

A summary of output most likely to be required by users. Known issue in timestep 1 - just ignore those values. This will be fixed in a future release.

Col 1: Timestep

Col 2: Row. Together with the column these values can be used to create a raster map of the output.

Col 3: Column.

Col 4: Ecoregion.

Col 5: ABio. Aboveground biomass stocks (gC/m2)

Col 6: BBio. Belowground (root) biomass stocks (gC/m2)

Col 7: TotalDOM. Total dead organic matter and soil stocks (gC/m2)

Col 8: DelBio. Annual change in biomass stocks (gC/m2/yr).

Col 9: Turnover. Annual transfer of biomass (above-and belowground) to dead organic matter and soil pools when disturbance = 0 (gC/m2/yr)

Col 10: NetGrowth Annual growth increment (gC/m2/yr), Bio(t, prior to growth) - Bio(t, end of year). DelBio and NetGrowth will be the same when there are no losses caused by disturbances.

Col 11: NPP. Net Primary Production (includes above and belowground) (gC/m2/yr). This is calculated from the growth of aboveground biomass, roots and replacement of litterfall and annual turnover.

Col 12: Rh. Heterotrophic respiration (gC/m2/yr). This is the sum of the “To Air” fluxes when disturbance = 0.

Col 13: NEP. Net Ecosystem Productivity (gC/m2/yr). NPP minus Rh.

Col 14: NBP. Net Biome Productivity (gC/m2/yr). NEP minus losses from the ecosystem due to disturbances: both emissions to air from combustion and losses to the forest products sector.

4.3. log_BiomassC.csv

This file gives information about the biomass C of each site (gC/m^2), by cohort.

Col 1: Time

Col 2: Row Together with the column these values can be used to create a raster map of the output.

Col 3: Column

Col 4: Ecoregion

Col 5: Species

Col 6: Age

Col 7: Wood Woody biomass

Col 8: Leaf Leaf biomass

Col 9: CrsRoot Coarse root biomass

Col 10: FineRoot Fine root biomass

4.4. log_Pools.csv

This file gives information about the DOM and soil C stocks of each site by species (gC/m^2).

Col 1: Time

Col 2: row

Col 3: column

Col 4: ecoregion

Col 5: species

Col 6: VF_A Very fast aboveground pool C

Col 7: VF_B Very fast belowground pool C

Col 8: Fast_A Fast aboveground pool C

Col 9: Fast_B Fast belowground pool C

Col 10: MED Medium pool C

Col 11: Slow_A Slow aboveground pool C

Col 12: Slow_B Slow belowground pool C

Col 13: Sng_Stem Snag stem pool C

Col 14: Sng_Oth Snag other pool C

Col 15: Extra “Extra” pool C. This should be 0 unless you have explicitly initialized it or asked for material to be transferred into this pool after a disturbance.

4.5. log_Flux.csv

Col 1: Time

Col 2: row

Col 3: column

Col 4: ecoregion

Col 5: species

Col 6: Dist Disturbance type: 0 = none (i.e., fluxes from normal growth and mortality), 1=fire, 2=harvest, 3=wind, 4=bda

Col 7: VF_A_toAir Release from the very fast aboveground DOM pool to air

Col 8: VF_A_toSlow Transfer from the very fast aboveground DOM pool to Slow aboveground pool

Col 9: VF_B_toAir Release from the very fast belowground DOM pool to air

Col 10: VF_B_toSlow Transfer from the very fast belowground DOM pool to Slow belowground pool

Col 11: Fast_A_toAir Release from the fast aboveground DOM pool to air

Col 12: Fast_A_toSlow Transfer from the fast aboveground DOM pool to Slow aboveground pool

Col 13: Fast_B_toAir Release from the fast belowground DOM pool to air

Col 14: Fast_B_toSlow Transfer from the fast belowground DOM pool to Slow belowground pool

Col 15: MED_toAir Release from the medium DOM pool to air

Col 16: MED_toSlow Transfer from the medium DOM pool to Slow aboveground pool

Col 17: Slow_A_toAir Release from the slow aboveground DOM pool to air

Col 18: Slow_A_toSlow Transfer from the slow aboveground DOM pool to Slow belowground pool

Col 19: Slow_B_toAir Release from the slow belowground DOM pool to air

Col 20: Slow_B_toSlow unused

Col 21: Sng_Stem_toAir Release from the snag stems pool to air

Col 22: Sng_Stem_toSlow Transfer from the snag stems pool to Slow aboveground pool

Col 23: Sng_Stem_toMed Transfer from the snag stems pool to the medium DOM pool

Col 24 Sng_Oth_toAir Release from the snag other pool to air

Col 25 Sng_Oth_toSlow Transfer from the snag other pool to Slow aboveground pool

Col 26 Sng_Oth_toFast Transfer from the snag other pool to Fast aboveground pool

Col 27: Extra_toAir Extra DOM pool to air

Col 28: Extra_toSlow Extra DOM pool to slow aboveground pool

Col 29: BioToFPS Transfer of biomass C to the forest product sector

Col 30: SnagsToFPS Transfer of snag C to the forest product sector

Col 31: DOMtoFPS Transfer of DOM other than stem snags C to the forest product sector

Col 32: MERCH_ToDOM Transfer of C from merchantable live biomass stem snags pool

Col 33: MERCH_ToAir Release of C from merchantable live biomass to the air

Col 34: FOL_ToDOM Transfer of C from the foliage to very fast aboveground pool

Col 35: FOL_ToAir Release of foliage C to the air

Col 36: OtherWoody_ToDOM Transfer of other live woody C to the snag other and fast aboveground

Col 37: OtherWoody_ToAir Release of other live woody C to air

Col 38: CrsRt_ToDOM Transfer of coarse root C to fast aboveground and fast belowground

Col 39: CrsRt_ToAir Release of coarse root C to air

Col 40: FRt_ToDOM Transfer of fine root C to very fast aboveground and very fast belowground

Col 41: FRt_ToAir Release of fine root C to air

5. Example Output Files

5.1. ForCs-ANPP-Establishment-log.csv

Time	Ecoregion	Species	MaxANPP	MaxBiomass	ProbEst
1	eco1	pinubank	648	15053	0.1
1	eco1	querelli	1415	25161	0.1
1	eco2	pinubank	648	15053	0.1
1	eco2	querelli	1415	25161	0.1
2	eco1	pinubank	648	15053	0.1
2	eco1	querelli	1415	25161	0.1
2	eco2	pinubank	648	15053	0.1
2	eco2	querelli	1415	25161	0.1
3	eco1	pinubank	648	15053	0.1
3	eco1	querelli	1415	25161	0.1
3	eco2	pinubank	648	15053	0.1
3	eco2	querelli	1415	25161	0.1
4	eco1	pinubank	648	15053	0.1

5.2. log_Summary.csv

Values are reported in g C m^{-2}. Known problem in timestep 1 - just ignore those values.

Time	row	column	ecoregion	ABio	BBio	TotalDOM	DelBio	Turnover	NetGrowth	NPP	Rh	NEP	NBP
2	1	1	0	313	126.1	8320.3	47	36.5	47	83.5	80.9	2.6	2.6
2	1	2	0	313	126.1	8320.3	47	36.5	47	83.5	80.9	2.6	2.6
2	1	3	1	313	126.1	8320.3	47	36.5	47	83.5	80.9	2.6	2.6
2	1	4	1	6416	1873.5	13378.9	10.3	479.9	10.3	490.2	426.4	63.9	63.9
2	1	5	1	6416	1873.5	13378.9	10.3	479.9	10.3	490.2	426.4	63.9	63.9
2	1	6	1	2157.5	934.2	5614	179.1	162.2	179.1	341.3	154.3	187	187
2	1	7	1	2157.5	934.2	5614	179.1	162.2	179.1	341.3	154.3	187	187
2	1	8	1	279.5	112.6	16790.4	-7887	32.7	41.4	74.1	754.9	-680.8	-4772.7
2	1	9	1	279.5	112.6	16790.3	-7887.6	32.7	41.4	74.1	754.9	-680.8	-4772.9
2	2	1	0	313	126.1	8320.3	47	36.5	47	83.5	80.9	2.6	2.6
2	2	2	0	313	126.1	8320.3	47	36.5	47	83.5	80.9	2.6	2.6

5.3. log_BiomassC.csv

Wood, Leaf, CrsRoot, and FineRoot are reported in g C m^{-2}.

Time	row	column	ecoregion	species	Age	Wood	Leaf	CrsRoot	FineRoot
1	1	1	0	querelli	112	5738	637.6	1530.1	382.5
1	1	2	0	querelli	112	5738	637.6	1530.1	382.5
1	1	3	1	querelli	112	5738	637.6	1530.1	382.5
1	1	4	1	querelli	212	3851.6	428	1027.1	256.8
1	1	4	1	querelli	2	181.8	20.2	48.5	12.1
1	1	5	1	querelli	212	3855.6	428.4	1028.2	257
1	1	6	1	pinubank	12	464	51.6	123.7	30.9
1	1	7	1	pinubank	12	464	51.6	123.7	30.9
1	1	8	1	querelli	212	3855.6	428.4	1028.2	257
1	1	9	1	pinubank	12	464	51.6	123.7	30.9
1	2	1	0	querelli	112	5738	637.6	1530.1	382.5
1	2	2	0	querelli	112	5738	637.6	1530.1	382.5
1	2	3	1	querelli	112	5738	637.6	1530.1	382.5

5.4. log_Pools.csv

Values are reported in g C m^{-2}.

Time	row	col	eco	species	VF_A	VF_B	Fast_A	Fast_B	MED	Slow_A	Slow_B	Sng_Stem	Sng_Oth	Extra
1	1	1	0	querelli	398.8	14.5	722.3	1084.2	4163.8	4930.2	3847.1	2189.1	315.7	0
1	1	2	0	querelli	398.8	14.5	722.3	1084.2	4163.8	4930.2	3847.1	2189.1	315.7	0
1	1	3	1	querelli	405	14.6	730.3	1087.8	4169.8	4926.2	3850.3	2200.7	316.7	0
1	1	4	1	querelli	236.2	11	602.7	1032.3	5848.2	6185.3	3486.3	1707.1	257	0
1	1	5	1	querelli	231.1	11	602.5	1032.2	5848.2	6185.1	3486.3	1706.1	256.8	0
1	1	6	1	pinubank	46.3	3.5	1046	1032.6	2466.2	2308.3	7597.9	3056.3	379.1	0
1	1	7	1	pinubank	46.3	3.5	1046	1032.6	2466.2	2308.3	7597.9	3056.3	379.1	0
1	1	8	1	querelli	231.1	11	602.5	1032.2	5848.2	6185.1	3486.3	1706.1	256.8	0
1	1	9	1	pinubank	46.1	3.5	1043.3	1031.9	2464.8	2309.7	7595.4	3052	378.6	0
1	2	1	0	querelli	398.8	14.5	722.3	1084.2	4163.8	4930.2	3847.1	2189.1	315.7	0
1	2	2	0	querelli	398.8	14.5	722.3	1084.2	4163.8	4930.2	3847.1	2189.1	315.7	0
1	2	3	1	querelli	406	14.8	726.1	1084.7	4156.2	4926.6	3841.2	2194.5	316.5	0
1	2	4	1	pinubank	46.1	3.5	1043.3	1031.9	2464.8	2309.7	7595.4	3052	378.6	0
1	2	5	1	querelli	231.1	11	602.5	1032.2	5848.2	6185.1	3486.3	1706.1	256.8	0
1	2	6	1	pinubank	46.1	3.5	1043.3	1031.9	2464.8	2309.7	7595.4	3052	378.6	0
1	2	7	1	pinubank	46.3	3.5	1046	1032.6	2466.2	2308.3	7597.9	3056.3	379.1	0
1	2	8	1	querelli	231.1	11	602.5	1032.2	5848.2	6185.1	3486.3	1706.1	256.8	0
1	2	9	1	pinubank	46.1	3.5	1043.3	1031.9	2464.8	2309.7	7595.4	3052	378.6	0
1	3	1	0	querelli	396.1	14.3	724.3	1087.3	4166.6	4930.1	3846.9	2192.5	315.6	0
1	3	2	0	querelli	396.1	14.3	724.3	1087.3	4166.6	4930.1	3846.9	2192.5	315.6	0

5.1. log_Flux.csv

Values are reported in g C m^{-2} yr^{-1}.

part 1

Time	row	column	ecoregion	species	Dist	VF_A_toAir	VF_A_toSlow	VF_B_toAir	VF_B_toSlow	Fast_A_toAir	Fast_A_toSlow	Fast_B_toAir	Fast_B_toSlow	MED_toAir	MED_toSlow	Slow_A_toAir	Slow_A_toSlow	Slow_B_toAir	Slow_B_toSlow
1	1	1	0	querelli	0	4.423	1.004	3.349	0.686	0.154	0.031	1.626	0.333	18.211	3.73	9.429	23.657	37.824	0
1	1	2	0	querelli	0	4.423	1.004	3.349	0.686	0.154	0.031	1.626	0.333	18.211	3.73	9.429	23.657	37.824	0
1	1	3	1	querelli	0	4.421	1.004	3.349	0.686	0.154	0.031	1.626	0.333	18.211	3.73	9.429	23.657	37.824	0
1	1	4	1	querelli	0	124.076	28.164	46.502	9.524	77.854	15.946	11.886	2.434	20.643	4.228	12.401	31.113	36.414	0
1	1	5	1	querelli	0	124.076	28.164	46.502	9.524	77.854	15.946	11.886	2.434	20.643	4.228	12.401	31.113	36.414	0
1	1	6	1	pinubank	0	64.049	14.539	35.836	7.34	3.843	0.787	3.784	0.775	8.766	1.795	6.132	15.386	25.393	0
1	1	7	1	pinubank	0	64.049	14.539	35.836	7.34	3.843	0.787	3.784	0.775	8.766	1.795	6.132	15.386	25.393	0
1	1	8	1	querelli	0	124.076	28.164	46.502	9.524	77.854	15.946	11.886	2.434	20.643	4.228	12.401	31.113	36.414	0
1	1	9	1	querelli	0	124.073	28.164	46.505	9.525	77.844	15.944	11.886	2.435	20.641	4.228	12.401	31.112	36.414	0
1	2	1	0	querelli	0	4.423	1.004	3.349	0.686	0.154	0.031	1.626	0.333	18.211	3.73	9.429	23.657	37.824	0
1	2	2	0	querelli	0	4.423	1.004	3.349	0.686	0.154	0.031	1.626	0.333	18.211	3.73	9.429	23.657	37.824	0
1	2	3	1	pinubank	0	105.778	24.011	69.137	14.161	39.873	8.167	9.162	1.877	10.019	2.052	7.996	20.06	29.527	0
1	2	4	1	querelli	0	250.031	56.756	62.138	12.727	238.86	48.923	32.222	6.6	25.923	5.309	12.551	31.488	36.523	0
1	2	4	1	querelli	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2	5	1	querelli	0	124.076	28.164	46.502	9.524	77.854	15.946	11.886	2.434	20.643	4.228	12.401	31.113	36.414	0
1	2	6	1	querelli	0	124.073	28.164	46.505	9.525	77.844	15.944	11.886	2.435	20.641	4.228	12.401	31.112	36.414	0
1	2	7	1	pinubank	0	64.049	14.539	35.836	7.34	3.843	0.787	3.784	0.775	8.766	1.795	6.132	15.386	25.393	0

part 2

Sng_Stem_toAir	Sng_Stem_toSlow	SngStemToMed	Sng_Oth_toAir	Sng_Oth_toSlow	SngOthToFast	Extra_toAir	Extra_toSlow	BioToFPS	SnagsToFPS	DOMtoFPS	MERCH_ToDOM	MERCH_ToAir	FOL_ToDOM	FOL_ToAir	OtherWoody_ToDOM	OtherWoody_ToAir	CrsRt_ToDOM	CrsRt_ToAir	FRt_ToDOM	FRt_ToAir
0.201	0.041	0.14	0.018	0.004	0.043	0	0	0	0	0	0	0	10.552	0	0	0	1.847	0	20.275	0
0.201	0.041	0.14	0.018	0.004	0.043	0	0	0	0	0	0	0	10.552	0	0	0	1.847	0	20.275	0
0.201	0.041	0.14	0.018	0.004	0.043	0	0	0	0	0	0	0	10.542	0	0	0	1.847	0	20.275	0
73.172	14.987	46.467	23.311	4.774	48.134	0	0	0	0	0	141.937	0	95.815	0	96.181	0	33.68	0	112.268	0
73.172	14.987	46.467	23.311	4.774	48.134	0	0	0	0	0	141.937	0	95.815	0	96.181	0	33.68	0	112.268	0
0.12	0.025	0.084	0	0	0.001	0	0	0	0	0	0	0	44.457	0	0	0	14.433	0	95.048	0
0.12	0.025	0.084	0	0	0.001	0	0	0	0	0	0	0	44.457	0	0	0	14.433	0	95.048	0
73.172	14.987	46.467	23.311	4.774	48.134	0	0	0	0	0	141.937	0	95.815	0	96.181	0	33.68	0	112.268	0
73.161	14.985	46.46	23.308	4.774	48.127	0	0	0	0	0	141.926	0	95.807	0	96.173	0	33.683	0	112.277	0
0.201	0.041	0.14	0.018	0.004	0.043	0	0	0	0	0	0	0	10.552	0	0	0	1.847	0	20.275	0
0.201	0.041	0.14	0.018	0.004	0.043	0	0	0	0	0	0	0	10.552	0	0	0	1.847	0	20.275	0
33.68	6.898	21.326	10.856	2.223	22.352	0	0	0	0	0	67.225	0	45.982	0	45.554	0	26.818	0	166.433	0
32.321	6.62	0	64.836	13.28	0	0	0	0	0	0	0	0	10.542	0	0	0	1.847	0	20.275	0
0	0	580.751	0	0	481.27	0	0	3202.852	871.127	0	683.584	0	640	0	1874.063	0	1682.051	0	186.895	0
73.172	14.987	46.467	23.311	4.774	48.134	0	0	0	0	0	141.937	0	95.815	0	96.181	0	33.68	0	112.268	0
73.161	14.985	46.46	23.308	4.774	48.127	0	0	0	0	0	141.926	0	95.807	0	96.173	0	33.683	0	112.277	0
0.12	0.025	0.084	0	0	0.001	0	0	0	0	0	0	0	44.457	0	0	0	14.433	0	95.048	0