Technical report Firewood-LANDIS – February-March 2019

This document reports notes on the preparation of the simulations with the forest landscape model LANDIS-II, and the steps for parameterizing its submodules Forest Carbon Succession (Dymond et al. 2012) and Base-Harvest in the context of the project “*Bois de Chauffage*”, Université du Quebec en Outauais UQO. The simulation study was performed in two landscapes: Outauais (MRC-Outa) and Quebec Centre – Mauricie (MRC-Centre).

The document also includes considerations for potential improvements beyond the administrative deadline of March 2019 and current model limitations that do not allow the representation of certain processes using present version of LANDIS extensions.

1. **Preparation of model inputs and preliminary parameterization of Forest Carbon Succession**

*Input maps and general LANDIS-II inputs.*

Initial communities and landtypes (i.e., LANDIS ecoregions) maps and associated input files for the two landscapes were derived by the team of Y. Boulanger following a procedure that have been previously tested and applied in previous studies (Boulanger et al. 2017; Tremblay et al. 2018). In addition, dynamic input parameters such as maxANPP, maximum biomass and probability of establishment by species and ecoregion were also derived by the team of Y. Boulanger using the forest patch model PICUS (Lexer and Honninger 2001).

*Forest Carbon Succession input file*

The Forest Carbon Succession extension (hereafter ForCS) requires one input file only (*ForC Succession*) containing nearly all the input parameters organized in tables. There are numerous parameters and some need to be specified by ecoregion and species. However, there are parameters that are identical as for the Biomass-succession extension, thus these were simply converted in the suitable format for ForCS. Here below are listed all the tables included in *ForC Succession* file with a brief description of the parameterization method. Since it was not possible to invest large amounts of time for the parameterization procedure, several parameters were set using default values and following recommendations in Dymond et al. (2015) and Kurz et al. (2009). Those parameters that can be potentially be improved are discussed in section 3)

* *AvailableLightBiomass*: prepared by the team of Y. Boulanger for Biomass-succession; converted in the suitable format for ForC Succession.
* *LightEstablishmentTable*: prepared by the team of Y. Boulanger for Biomass-succession; converted in the suitable format for ForC Succession.
* *SpeciesParameters*: Species were parameterized by deciduous VS evergreen (R.Tregaro, pers. comm.). For recommendations for further improvements see section 3.
* *Dead Organic Mater (DOM) Pools*: default values from Kurz et al. (2009).
* *EcoSppDOMParameters*: decay rates for each DOM Pool and Q10RefTemp10C were derived from default values form Kurz et al. (2009). The amount of DOM for each pool at the start of the simulation (Amount at T0) was initially set to zero and estimated with an iterative process at the beginning of the simulation (called “soil spin up”). For recommendations for further improvements see section 3.
* *ForCSProportions*: default values derived from Kurz et al. (2009) and Li et al. (2003).
* Set of tables that define how material is transferred out of different DOM, soil and Biomass pools after a disturbance (*DisturbFireTransferDOM*, *DisturbOtherTransferDOM*, *DisturbFireTransferBiomass,* *DisturbOtherTransferBiomass*): used values recommended by (Dymond et al. 2015). Since no disturbances other than harvesting will be considered in the project, there is no need to evaluate parameters for all type of natural disturbances. Se additional consideration in section 4.
* *ANPPTimeSeries*: prepared by the team of Y. Boulanger for Biomass-succession; converted in the suitable format for ForC Succession.
* *MaxBiomassTimeSeries*: prepared by the team of Y. Boulanger for Biomass-succession; converted in the suitable format for ForC Succession.
* *EstablishProbabilities*: prepared by the team of Y. Boulanger for Biomass-succession; converted in the suitable format for ForC Succession.
* *RootDynamics*: root:shoot ratios for each ecoregion and species were assigned with a constant value of 0.423 (average between 0.456 and 0.403 typical for temperate broadleaf forests <75 Mg/ha shoot biomass and temperate conifer forests <50 Mg/ha shoot biomass respectively) from Mokany et al. (2006). Other parameters were taken from Kurz et al. (2009) and Li et al. (2003).

All parameters and notes are reported in the Excel file *ForCS\_parameterization.xlsx*.

*Climate table*

This is the only additional input file required by the ForCS extension. Although the file must comply with the format requirements of the LANDIS climate library, ForCS needs only mean annual temperatures for modeling carbon decomposition. Climate data were derived for PICUS simulations (mean monthly temperature, monthly precipitation, solar radiation, and VPD), we averaged these variables for the year 2010 and used to build the Climate Table required for ForCS.

1. **Simulation setup and testing**

*Initializing Soil and DOM Carbon Pools*

At the beginning of a scenario, the initial communities begin with a certain amount of biomass for each cell within the simulated landscape. While living biomass it is typically calculated with a *spin up* process also in other LANDIS extensions, ForCS requires also initial carbon stocks for soil and DOM pools (10 pools) at the start of the simulation. These data are rarely available from field work; thus, the model can calculate them with an indipendent *soil spin up* process. However, this is a computationally intensive process that may requires significant time and computer resources and it is recommended to do it only once in case of complex landscapes. Following instructions by Dymond et al. (2015), we:

1. Set *AmountAtT0* values in EcoSppDOMParameters table in ForC Succession input file to 0,
2. Ran a simulation for 1 year using soil spin up;
3. Save simulated DOM and soil pools (log\_Pools.csv) at year 0
4. Transfer the values in *AmountAtT0* values in EcoSppDOMParameters table in ForC Succession input file.

Now simulations can be run without the need to compute initial soil spin up, saving a consistent amount of time and computer resources.

This was the first time that this approach was applied since the development of ForCS (C. Dymond, pers. comm.) In order to reach an operational phase in relatively short time, these aspects were here not further explored. However, a more robust estimation of initial soil and DOM pools could be completed beyond March 2019 (see section 3).

*Testing simulations and extensions compatibility*

At the time of developing the simulation framework (March 2019), Forest Carbon Succession has not been made available with the latest version of LANDIS-II, v.7.0. Developers of ForCS confirmed that a new version compatible with LANDIS-II v7.0 is under development but not yet tested and released (C. Dymond, pers. comm.). Thus, simulations were run with LANDIS-II v.6.2.

First, simulations were run without harvesting to test ForCS under different scenarios length and time steps. Then, we proceeded with preparing harvesting prescriptions using the Base Harvest extension (Gustafson et al. 2000) and executed some test simulations for the landscape MRC-Centre using preliminary Base Harvest inputs. Finally, the Base Harvest inputs and management inputs maps were prepared for both landscapes and simulations were run for a scenario of 100 years on a 5-years time step.

*Simulation outline*

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1. **Potential improvements**

This section lists the possible improvements for obtaining more robust simulations with ForCS in the context of the project. These improvements are feasible beyond March 2019 pending the investment of time.

* Better estimates of soil and DOM pools at the beginning of the simulations and improve the soil spin-up process. This can be done by using a simplified initial communities file composed of cohorts having maximum age following guidelines in Dymond et al. (2015).
* Improved species parameters parameters in ForCS, by investing more time into literature analysis (see references in file *ForCS\_parameterization.xlsx*)
* Improved parameters in the RootDynamics table within input file ForCS
  + More robust estimates of Root:Shoot ratios. Values can be derived for each ecoregion and species based on the vegetation category and shoot biomass (aboveground biomass in t/ha initial communities)
  + Improve other parameters such as *PropFineRt*, *Frturnover*, *Crturnover* using literature sources (Li et al. 2003)
* Improve the spatial pattern of simulated harvesting by defining stands within management areas and cell-spreading functions.

1. **Model limitations**

This section reports briefly processes that were not possible to account for due to limitations in the structure and compatibility of the model

* The Biomass Harvest extension (Scheller and Domingo 2018) was not compatible with ForCS. Thus, it was not possible to simulate partial harvesting.
* It was not possible to obtain biomass maps as direct model output, as ForCS is currently not compatible with the multiple Biomass Output extensions.
* Forest carbon Succession allows the user to define how material is transferred out of different biomass and soil DOM pools after a disturbance. However, it does not allow differentiating these transfers by different harvesting prescriptions (e.g., stem wood might be transferred to long-term storage Forest Product Sector after a timber harvesting prescription but to Air instead after a firewood prescription).

1. **References**

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