Partner Data Request Guidance Document

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November 2024

DIVERSE

To achieve the DIVERSE Project's research goals, Theme 4 will use modeling tools (i.e., LANDIS-II) to estimate and predict the effect(s) of Business-As-Usual (BAU), Climate-Smart Forestry (CSF), and Functional Complex Network (FCN) management strategies on Canadian forests.

LANDIS-II requires extensive data to parameterize and calibrate vegetation dynamics and future projections. To meet this need, we are collaborating closely with project partners, leveraging our network to acquire these essential data.

In return, the data will provide valuable insights to help answer partners' questions about the future of Canadian forests and how to enhance their resilience.

This document outlines the data needed from project partners and explains its critical role in parameterized forest landscape model LANDIS-II.

Note: To clarify the types of datasets required, we include visual examples of the data used for LANDIS-II parameterization in Québec.

You can find a short video recording where we present the LANDIS-II model and its functioning, along with explanation about its input data with this link.

Table of Contents

Need #1: Forest Inventory Data

Purpose: Forest inventory data will be used to establish the initial conditions for each LANDIS-II simulation and to validate the model's parameters. These initial conditions include the tree species composition and age cohorts for each species within each pixel (100x100m) of the landscape model.

Data Requirements: The DIVERSE team would need landscape-wide forest inventory data that provides estimates of tree species and age cohorts for each forest stand within the Forest Management Area (FMA) managed by the partner.

Ideally, the data would include:

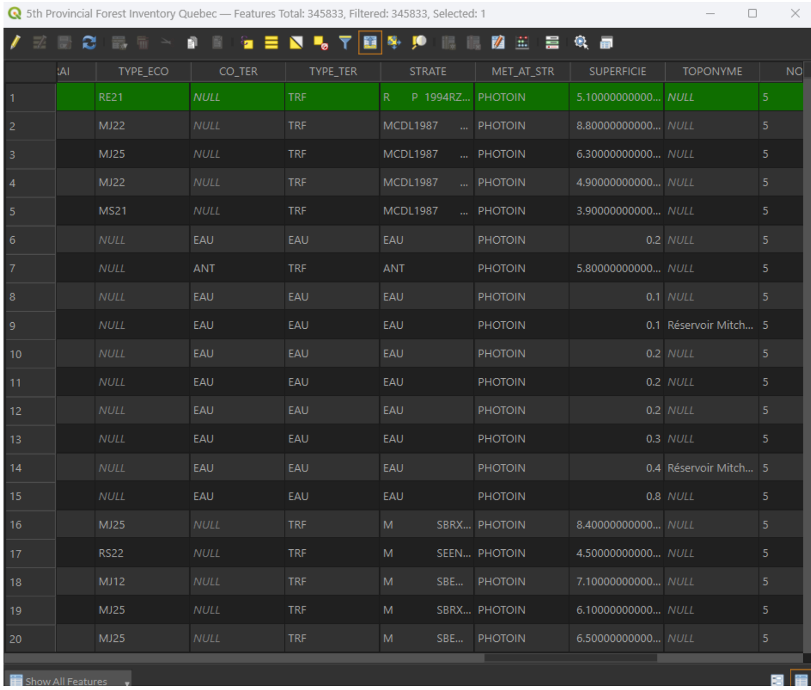
- Tree species composition (by stand);
- Estimates of stand age; and
- Age of individual trees.

If the existing inventory data do not include the age of individual trees, we will require as much additional context as possible on the forest stands and sample plot data. This site-specific data could include:

- Elevation;
- Slope;
- Climate; and
- Soil.

We will then use a *k-NN* (*k-N*earest-*N*eighbor approach) assignation method to assign the more precise sample plot data to the forest stands to estimate their composition (see Boulanger *et al.* 2017 for an example of this method).

Example: In Québec, data from the 5th Provincial Forest Inventory, along with sample plot data, was used to set up the initial conditions for LANDIS-II simulations (see Boulanger *et al.* 2017). This inventory data are a large spatial data set containing polygons that represent forest stands or other land use types (urban areas, agriculture, etc.). Each polygon is associated with extensive attributes regarding forest stand composition, most derived photo-interpreted or computed through assignation methods such as the *k-NN* assignation).



5th Provincial Forest Inventory Quebec — Features Total: 345833, Filtered: 345833, Selected: 1

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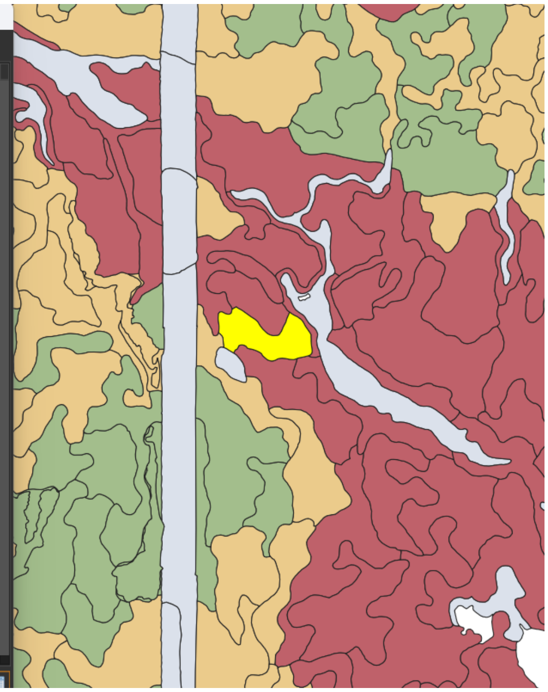

Figure: Québec (LEFT)Table of attributes for the polygons, which contains information regarding the age, composition, and abiotic attributes (slope, soil) of the forest stand. (RIGHT) Image of forest stands, identified by unique polygons.

Need #2: Sample Plot Data & Local Tree Growth Curves

Purpose: Sample plot data and growth curves are essential not only for defining the initial conditions of LANDIS-II simulations but also for calibrating and verifying the vegetation dynamics generated by the model.

Data Requirements: We require sample plot data and local tree growth curves for as many species and forest types as possible, both within and outside of the FMA (but still within the region), and on the longest timeline possible, up to the present. Ideally, sample plot data should include information about any natural or human disturbances that plots have experienced, which can be provided through other datasets (see Needs #4 and #5 below).

Example: In Québec, data from both permanent and temporary sample plots (PSP and TSP), along with the 5th provincial forest inventory, were used to establish the initial conditions of LANDIS-II simulations (see Boulanger *et al.* 2017). This data is stored in a comprehensive geodatabase that links various tables to plot attributes of the plots, down to the characteristics of individual trees measured within the plots.

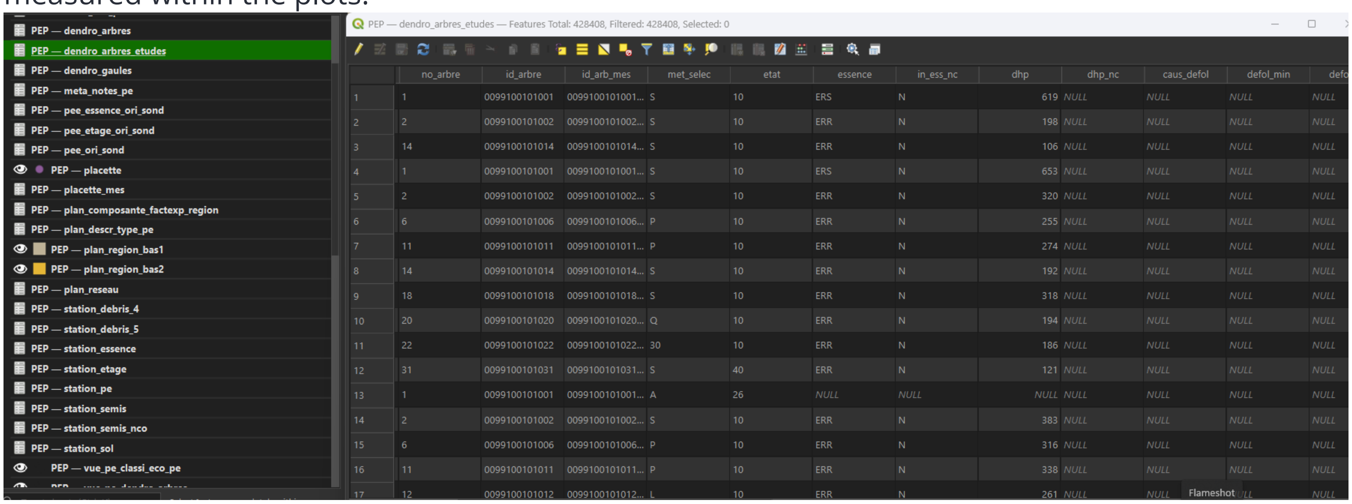

Figure: Québec (LEFT) Displays the different data tables that are all linked together through unique keys for the different sample plots. (RIGHT)A sample of attributes in a particular table. These attributes concern the plot, but also the individual tree measures in the plot during surveys.

Local growth curves (also referred to as yield curves or yield tables) from Québec's Ministry of Forests were used by Ameray *et al.* (2023) to calibrate the parameters of PnET succession module[1] within LANDIS-II. These empirical curves capture species growth patterns over time under different local conditions (soil, species mixture, etc.).

[1] The PnET model is an ecophysiological model used to predict the growth of individual trees under different conditions, including different species mixtures. It does so through complex algorithms of competition for light and water which allow for the emergence of different strategies of competition for different tree species.

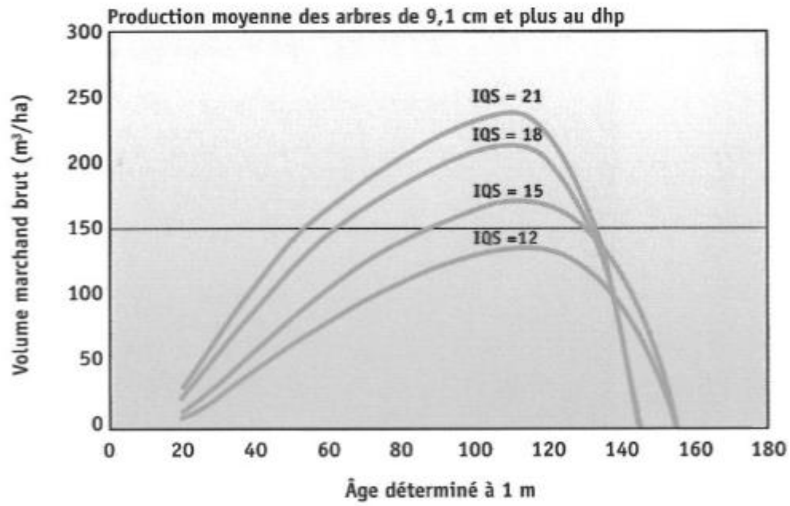

Figure: Growth curve from (Pothier et Savard, 1998) showing the evolution of the brut merchantable volume (m^3/ha, y-axis) through the age of a tree (Aged determined at 1m height, x-axis).

Need #3: Soil Inventory Data

Purpose: Soil data are essential for modeling vegetation dynamics across large landscapes. The DIVERSE project will utilize the PnET succession extension of LANDIS-II, which models soil composition to calculate water retention capacity for each simulated pixel.

Data Requirements: We need soil composition estimates for forest stands within the FMA, including:

- Proportions of gravel, sand, and clay;
- Soil density; and
- Organic matter content.

If detailed composition data is unavailable, we can use soil texture classifications based on Food and Agriculture Organization of the United Nations (FAO, 2006) or the United States Department of Agriculture (USDA, 1999). These can include the following classifications: sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.

Example: In Québec, soil data from Duchesne & Ouimet (2021) were used by Ameray *et al.* (2023) to define the soil characteristics for three simulated areas within the province, enabling effective use of the PnET Succession extension of LANDIS-II.

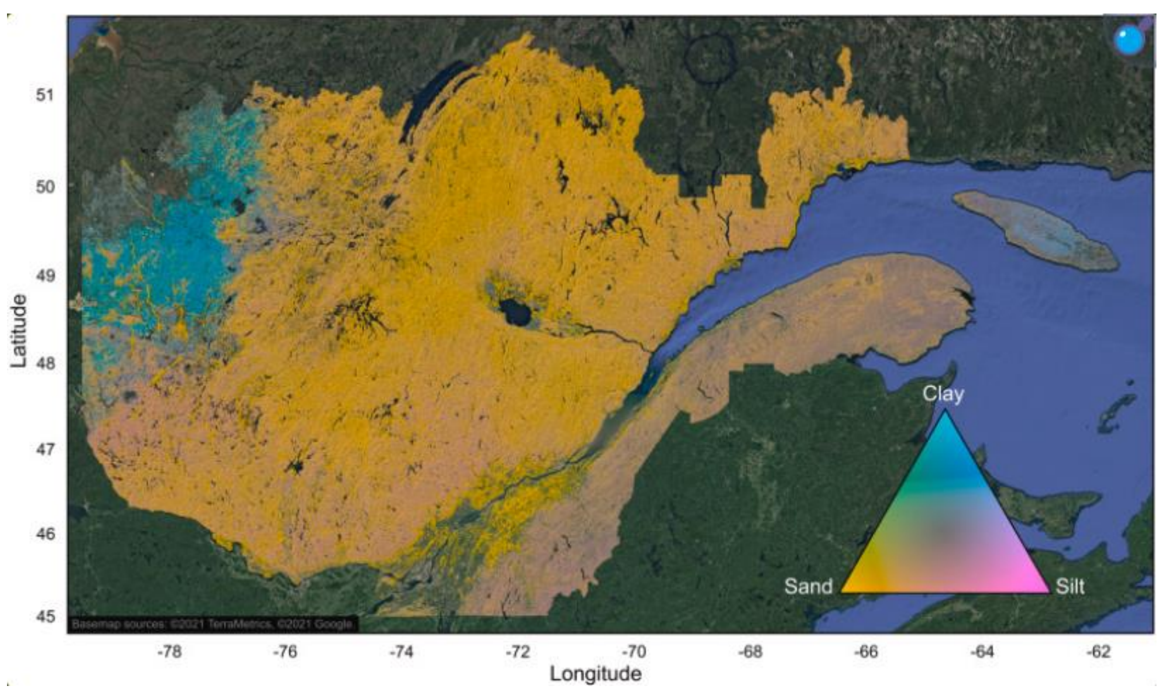

Figure: Map from Duchesne & Ouimet (2021) showing the variation in soil texture throughout the south of the province of Québec.

Need #4: Natural Disturbances Data

Purpose: Natural disturbances play critical roles in forest dynamics, particularly in Canada. Many disturbances, such as fire, insect outbreaks, droughts, windthrow, and others, can be represented within LANDIS-II simulations to accurately model their frequency, spatial distribution, and severity required for parameterizing the disturbance modules within LANDIS-II.

Data Requirements: We need spatial and temporal records of all natural disturbances that have occurred within the partner FMA.

If detailed records are not available, annual estimates of the affected forest area or data on live biomass killed or merchantable volume lost due to these disturbances will be needed.

Example: In Québec, the Ministry of Forests maintains an up-to-date spatial database documenting every fire larger than 0.1ha in certain regions. This resource has been instrumental in multiple studies to calibrate the fire extensions within LANDIS-II.

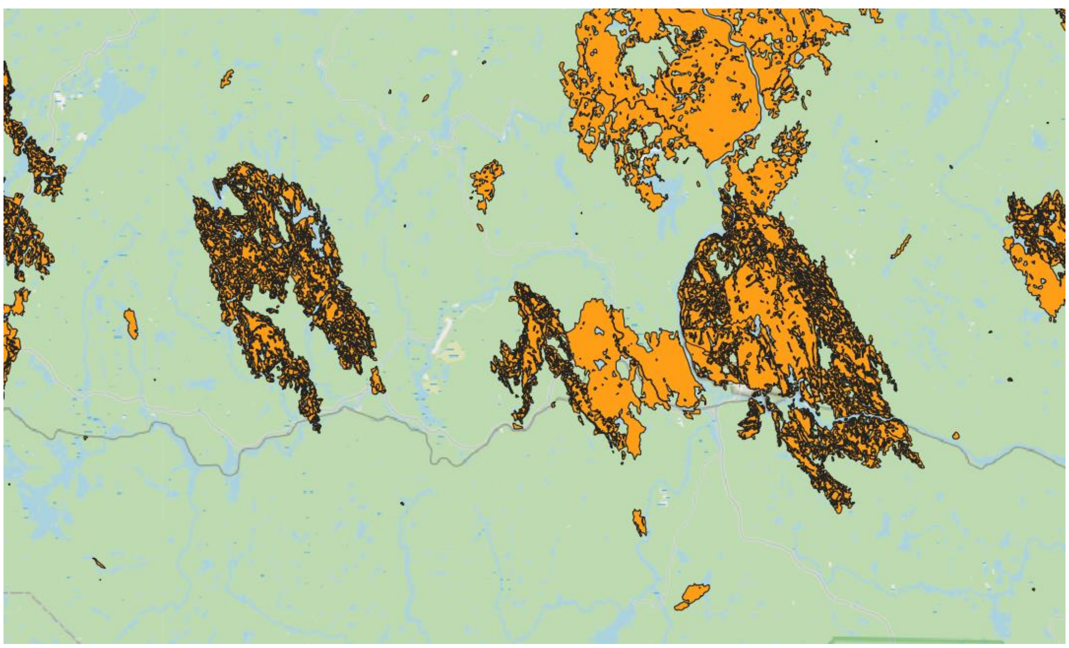

Figure: Map showing some polygons from the forest fire database of the Ministry of forests of Québec. Each polygon corresponds to the area affected by a specific fire event in Québec.

Need #5: Forest Harvesting Data (past and present)

Purpose: Similar to natural disturbances, forest harvesting is a major factor shaping Canadian forests. The DIVERSE project will test various forest management strategies, and to refine these and compare them to BAU scenarios (see above), we need data on past and present harvesting practices within the FMA.

Data Requirements: We require spatial and temporal records of all forest operations within the FMA, including:

- Area affected;
- Year of operation; and
- Type of harvest (e.g., clearcut, retention, etc.).

Additionally, data on forest road construction, including costs under varying conditions (e.g., slope, road size), would be valuable. This information will improve the modeling of forest roads and aid in exploring the economic aspects of the management scenarios.

Example: In Québec, the Ministry of Forests maintains a database documenting all forest treatments, which has been used to calibrate BAU scenarios in studies (see Hardy *et al.* 2023) and to design realistic yet innovative management scenarios.

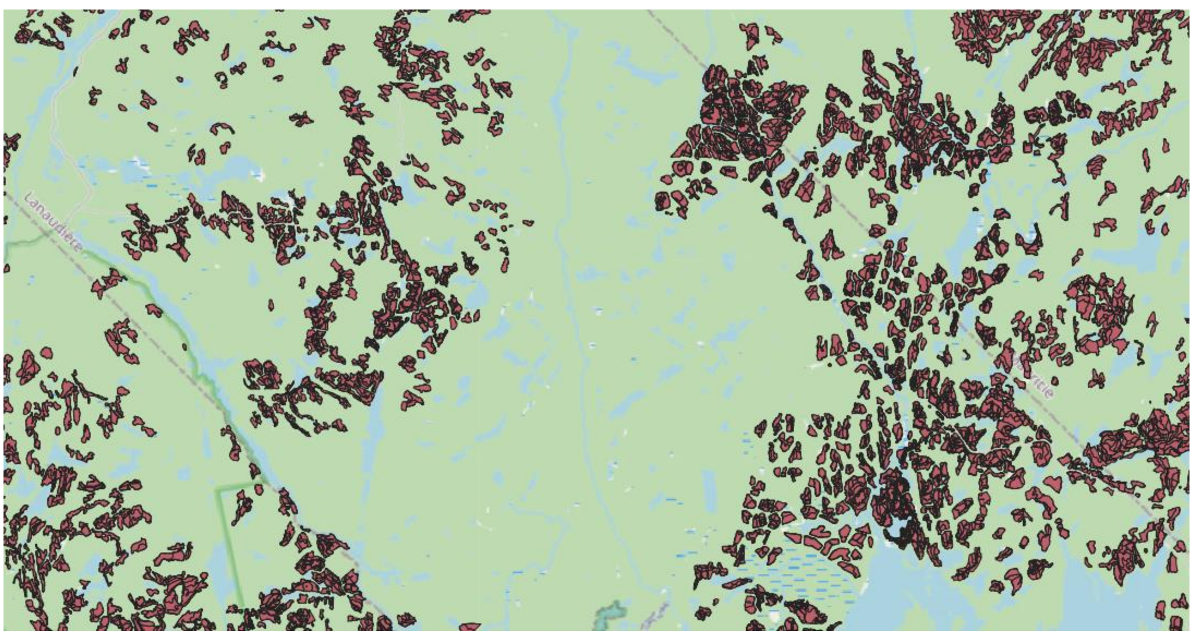

Figure: Map showing some polygons from the database of forestry interventions from the Ministry of forest of Québec. Each polygon represents a forest intervention of treatment (cut, plantation, education, etc.) in a forest stand.

Need #6: Land Use Data

Purpose: Forests are increasingly surrounded by human activities that impact their dynamics through habitat loss, fragmentation, pollution, invasive species, and the disturbance of native species While LANDIS-II does not directly simulate human land-use changes, it allows for landscape change modeling and can be integrated with models that simulate land-use transitions (e.g., State-and-Transition models, see Daniel et al. 2016). Additionally, LANDIS-II outputs on vegetation dynamics can be combined with land-use data to assess habitat quality for species of interest, among other applications.

Data Requirements: We need spatial data on land-use within the FMA, including:

- Urban areas (towns, city);
- Agriculture;
- Mining/Oil/Gas Operations;
- Roads; and
- Other Activities.

Examples In Québec, the 5th provincial Forest Inventory includes data on various forms of land occupation (e.g., mines, power lines, urban areas).

References

Ameray, A., Cavard, X. & Bergeron, Y. (2023). Climate change may increase Québec boreal forest productivity in high latitudes by shifting its current composition. *Frontiers in Forests and Global Change*, *6*. https://www.frontiersin.org/articles/10.3389/ffgc.2023.1020305

Boulanger, Y., Taylor, A. R., Price, D. T., Cyr, D., McGarrigle, E., Rammer, W., Sainte-Marie, G., Beaudoin, A., Guindon, L. & Mansuy, N. (2017). Climate change impacts on forest landscapes along the Canadian southern boreal forest transition zone. *Landscape Ecology*, *32*(7), 1415-1431. https://doi.org/10.1007/s10980-016-0421-7

Duchesne, L. & Ouimet, R. (2021). Digital mapping of soil texture in ecoforest polygons in Québec, Canada. *PeerJ*, *9*, e11685. https://doi.org/10.7717/peerj.11685

FAO. (2006). *Guidelines for soil description* (4th ed). Food and Agriculture Organization of the United Nations.

Hardy, C., Messier, C., Boulanger, Y., Cyr, D. & Filotas, É. (2023). Land sparing and sharing patterns in forestry: exploring even-aged and uneven-aged management at the landscape scale. *Landscape Ecology*, *38*(11), 2815-2838. https://doi.org/10.1007/s10980-023-01742-7

Pothier, D. & Savard, F. (1998). Actualisation des tables de production pour les principales espèces du Québec. *Gouvernement du Québec, ministère des Ressources naturelles, Bibliothèque nationale du Québec. RN98-3054*.

USDA. Soil Taxonomy : A Basic System of Soil Classification for Making and Interpreting Soil Surveys. https://www.nrcs.usda.gov/sites/default/files/2022-06/Soil%20Taxonomy.pdf 1999.