**A 249-year chronosequence of forest plots from eight successive fires in the Eastern Canada boreal mixedwoods**

Kobra Maleki1, 3, Philippe Marchand1, Danielle Charron2, Benoit Lafleur1, Yves Bergeron1, 2

1 Institute of Forest Research, University of Quebec in Abitibi-Temiscamingue, 445 boul. de l'Université, Rouyn-Noranda, QC J9X 5E4, Canada

2 Department of Biological Sciences, University of Quebec in Montreal, Montreal, QC H3C 3P8, Canada

3 Correspondence: e-mail: [kobra.maleki@uqat.ca](mailto:kobra.maleki@uqat.ca); Tel.: + 1 819 762 0971 Ext.2462

# **Metadata**

# **Class I. Data set descriptors**

## **A. Data set identity**

EASTERN BOREAL MIXEDWOODS CANADA: a data set originating from eight successive fires, representing a chronosequence of 249 years

## **B. Data set identification code**

DataS1.zip

## **C. Data set description**

**1. Principal originators:**

**1.** Yves Bergeron,

Institut de recherche sur les forêts, Université du Québec en Abitibi-Témiscamingue, 445 boul. de l'Université, Rouyn-Noranda, QC J9X 5E4, Canada and Département des sciences biologiques, Université du Québec à Montréal, Montréal, QC H3C 3P8, Canada

**2.** Danielle Charron,

Département des sciences biologiques, Université du Québec à Montréal, Montréal, QC H3C 3P8, Canada

**2. Abstract:** A combination of wildfires and defoliating insect outbreaks play an important role in the natural successional dynamics of North American boreal mixedwood forests, which, in the long term, change the post-disturbance composition and structure of forest stands. After stand-replacing disturbances (mainly wildfires), early successional hardwoods typically dominate the affected areas. Provided enough time following disturbances, the increasing recruitment of mid-to late-successional softwoods, as well as the mortality of hardwoods, gradually change forest composition from hardwoods to admixtures of hardwood-conifer species and conifer-dominated stands in mid and late successional stages, respectively. Such mixedwoods are abundant across the southern Canadian boreal forest. In boreal Canada, mixedwoods are the most structurally heterogeneous forest ecosystems, are highly productive, and form an important source of timber supply. Here we present the EASTERN BOREAL MIXEDWOODS CANADA dataset, which documents the changes in composition and structure of stands originating from eight different wildfires representing a chronosequence of 249 years, since the fire, in eastern Canada. This dataset has been used in several different projects to study and model the influence of natural (e.g., insect outbreaks) and anthropogenic disturbances (e.g., harvesting) on the dynamics of post-fire stands. The dataset covers a high range of variability in stand composition and structure, explained by species establishment, dominance, and mixture. It thus constitutes a useful source of information to trace the dynamics of the main boreal tree species of eastern North America, from their establishment to their replacement at different spatial scales (e.g., from stand to landscape level).

## **D. Keywords**

18th-20th century wildfires, boreal forests, composition, disturbance, long-term succession, North America, species dominance, structure

# **Class II. Research origin descriptors**

## **A. Overall project description**

**1. Identity:** A chronosequence of 249 years of forest succession in the boreal mixedwoods of eastern Canada

**2. Originators:** TheEASTERN BOREAL MIXEDWOODS CANADA data was coordinated by Yves Bergeron with the help of Danielle Charron.

**3. Period of study:** 1990-2019 (ongoing for LDRTF-SEEDLING\_PLOTS and LDRTF-HECTARES data sets)

**4. Objectives:** As our main objective, we compiled three existing LDRTF datasets (see the following Abstract for more details) into one. That helped to combine all available inventory data for the area, and present post-fire stand properties, such as structure, species composition, age and regeneration (e.g., density and survival rate of seedlings). Our data set provides a well-organized collection of sampling plots (Figure 1), with potential applications to visualize the natural successional dynamics of various boreal tree species within post-fire stands, which originated from eight different wildfires, and which have been influenced by different disturbances. The EASTERN BOREAL MIXEDWOODS CANADA data will be openly available for interested researchers to pursue inquiries in LDRTF post-fire stands from seedlings to mature trees.

|  |
| --- |
|  |
| **Figure 1.** Map of Lake Duparquet Research and Teaching Forest in western Quebec, Canada; showing the distribution of LDRTF-TRANSECTS in orange, LDRTF-SEEDLING\_PLOTS in red, and LDRTF-HECTARES in black. The years refer to the five years and the time that stands originated from those fires. |

**5. Abstract:** The dataset integrates data from inventories conducted during the period 1990-2019 throughout the Lake Duparquet Research and Teaching Forest (LDRTF), located in the balsam fir - white birch bioclimatic domain of Québec (Canada), where a dozen large wildfires occurred since 1760 (Bergeron 1991) (see Figure 1). Within the LDRTF site, the EASTERN BOREAL MIXEDWOODS CANADA data have been collected in three main subsets that cover different study objectives that contribute to a better understanding of post-fire stand successional dynamics (the full description of three data sets will follow in next sections):

1. LDRTF-TRANSECTS: These transects represent a network of 624 quadrats that covers the stands originated from eight wildfires that occurred from 1760 to 1964 (1760, 1797, 1823, 1847, 1870, 1916, 1944, and 1964). The original idea of establishing the quadrats in 1990-1991 was to study the compositional and structural variability of post-fire stands and changes over time, first with a chronosequence analysis (Bergeron and Dubuc 1989) and then by a stand-reconstruction approach (Bergeron 2000). The other objective of establishing the plots was to study the interaction between post-fire stand composition and secondary disturbances (Kneeshaw and Bergeron 1998). The quadrats were re-sampled in 2009 and were used in several studies, for example for parametrizing the SORTIE-ND forest simulator to simulate the natural successional dynamics of post-fire stands in LDFTF over long periods, both in the presence and absence of natural and anthropogenic disturbances (Poulin et al. 2007, Poulin and Messier 2008, Leduc and Coates 2013, Bose et al. 2015, Maleki et al. 2020). Notice that, during the first survey all soil types were included, however, only mesic or sub-hydric clay soils and occasional mesic loams were sampled during the second survey.
2. LDRTF-SEEDLING\_PLOTS: In each post-fire stand (1760, 1797, 1823, 1847, 1870, 1916, 1944, and 1964) a 400 m2 plot was established in 1991, in which annual observations of seedling recruitment and mortality were made in 16 one-m2 subplots located near the plot borders since 1997.
3. LDRTF-HECTARES: In six of the post-fire stands (1760, 1823, 1847, 1870, 1916, and 1944) a one-hectare permanent plot was first established in 1994 and re-measured at 4-6-year intervals. One of the goals for these data was to study the spatial patterns, age structure, and growth of species in each stand (Park et al. 2005).

**6. Source(s) of funding:** The Natural Sciences and Engineering Research Council of Canada (NSERC), Fonds de recherche du Québec – Nature et technologies (FRQNT) and LDRTF

## **B. Specific subproject description**

**1. Site description:**

a. Site type:

The study area is located in western Québec, Canada, more specifically within the balsam fir (*Abies balsamea* (L.)Mill.) - white birch (*Betula papyrifera* Marsh) bioclimatic domain (Saucier et al. 1998). Forests of the region are characterized by a mixed composition of boreal conifers and shade-intolerant hardwoods. More specifically, early successional stands are dominated by trembling aspen (*Populus tremuloides* Michx.), white birch, and jack pine (*Pinus banksiana* Lamb.), while balsam fir and eastern white cedar (*Thuja occidentalis* L.), in association with white spruce (*Picea glauca* [Moench] Voss) and black spruce (*P. mariana* [Mill.] B.S.P.), dominate the late-successional stands (Bergeron 2000).

b. Geography:

Lake Duparquet Research and Teaching Forest (LDRTF, FERLD in French): 790 19' W-790 30' W, 480 86' N-480 32' N

c. Habitat:

The site is located in the Abitibi region of north-western Quebec, Canada, at the southern limit of the boreal forest subzone (Saucier et al. 2003).

d. Geology, landform:

The region is characterized by the presence of extensive clay deposits from proglacial Lakes Barlow and Ojibway (Veillette 1994, Canada Soil Survey Committee 1998). Despite the existence of some small-scale soil heterogeneity, all plots are located on mesic clay soils (grey Luvisols) with moderate to good drainage (Aubin et al. 2005). non-clay soils in the area are limited to rocky hills that are overlain with reworked till (Kneeshaw and Bergeron 1998).

e. Watershed, hydrology:

The site lies entirely within the Abitibi River and James Bay watershed (MDDELCC 2017).

f. Site history:

In addition to the presence of native people in the Abitibi region during the last 6000 years, the research sites have never been the object of commercial logging and other silvicultural treatments. The main natural disturbances regime is characterized by the occurrence of wildfires and defoliating insect outbreaks (Bergeron et al. 2001); however, since the initiation of inventories, no significant fire or insect outbreak has occurred. The most recent outbreak of spruce budworm(*Choristoneura fumiferana* (Clem.)), defoliator of balsam fir and spruce, happened between 1972 and 1987, a few years before establishing the inventory plots (Morin et al. 1993). For hardwood stands, there is also a report of two years with dry summer and partial defoliation by the forest tent caterpillar (*Malacosoma disstria*), a defoliator of broadleaf species, particularly trembling aspen, in 2001 and 2002 (Harvey and Brais 2007, Bose et al. 2015).

g. Climate:

The regional climate is cold continental with a mean annual temperature of about 1.0°C, mean annual total precipitation around 985 mm, of which 30% falls during the growing season, and the average number of degree-days (> 5°C) around 1350 (Environment Canada 2017). The mean annual temperature is about -15°C in January and 18°C in July.

**2. Experimental or sampling design:**

LDRTF-TRANSECTS:

1. Design characteristics: The plots are quadratic with a size of 256 m2 (16 m×16 m) and are located every 50 m along transects set in each post-fire stand, where adult trees (stems ≥ 5cm and height > 1m) were tallied. Besides, within each plot, a 64 m2 (8 m×8 m) subplot was installed for sapling (stems ≤ 5cm and height > 1m) surveys, and 12 one-m2 (1 m×1 m) micro-plots were created to count seedlings (stems ≤ 1cm and height < 1m) number. Figure 2 illustrates the location of subplots and micro-plots within a quadrat in LDRTF\_TRANSECTS data.

|  |
| --- |
|  |
| **Figure 2.** The location of subplots and micro-plots within a quadrat in LDRTF\_TRANSECTS data. |

1. Permanent plots: The entire data set is permanent, where the centers of the quadrats are fixed and mapped by their longitude and latitude.
2. Data collection period(s): 624 plots were first established and sampled in 1991 and 432 of these plots were resampled 18 years later in 2009.

LDRTF-SEEDLING\_PLOTS:

1. Design characteristics: In each post-fire stand one 400-m2 (20 m × 20 m) quadratic plot was established in 1990. In 2019 the quadrats were enlarged to 6400 m2 (80 m × 80 m) to account for parent trees outside the plot boundaries (the expanded plots were just sampled and were not tagged and coordinated). For seedling surveys, starting from 1997, 16 one-m2 (1 m × 1 m) subplots were installed around the 400 m2 permanent quadrats. Every other subplot was scarified (the entire humus layer was removed in autumn to expose the mineral soil), leaving eight natural and eight scarified subplots. The alternation of natural and scarified plots aimed to control for the effect of the spatial variation in seed fall. Figure 3 illustrates the location of subplots around the quadrat in LDRTF\_SEEDLING\_PLOTS data.
2. Permanent plots: All 400 m2 plots and 1-m² subplots are permanent.
3. Data collection period(s): Since the establishment of the 400-m2 plots in 1990, they are re-sampled every 4 - 6 years whereas seedlings in the 1-m² subplots are tallied annually between June and early September of each year.

LDRTF-HECTARES:

1. Design characteristics: In each post-fire stand, a one-hectare plot was subjectively located in stand conditions that represent the average stand compositions observed in LDRTF-TRANSECTS plots, assumed to be the characteristic of each fire stand in the LDRTF area. The broad compositional changes from young to old stands were validated by dendrochronological studies of species turnover and fire dynamics at the LDRTF (e.g., Bergeron and Dubuc 1989, Bergeron and Charron 1994, Bergeron 2000, DeGrandpré et al. 2000).

|  |
| --- |
|  |
| **Figure 3.** Schematic of the LDRTF-SEEDLING\_PLOTS and 16 subplots installed on each of the eight post-fire sites, S refers to scarified subplots in red and N refers to natural subplots in blue. |

1. Permanent plots: All one-hectare plots are permanent.
2. Data collection period(s): Since the establishment of the one-hectare plots in 1994, they are re-sampled every 5 - 10 years. Therefore, to date, we have 3 to 4 censuses per plot.

**3. Research methods:**

LDRTF-TRANSECTS:

1. Field/laboratory: In each 256-m2 plot, all trees having a diameter at breast height (DBH) greater than 5 cm, alive or dead (standing or fallen with bark and branches intact), were identified to species and classified in 5-cm DBH classes. Sapling and seedlings were also tallied in 64 m2 subplots and 1-m2 micro-plots, respectively (Figure 2). Table 1 summarises the study plots according to fire-related characteristics, number of transects, and sampling plots per fire at first sampling in 1991. As previously mentioned, in the LDRTF region, a spruce budworm outbreak was reported for the period 1972-1987 that was very severe and killed an estimated 56% of balsam fir and spruce trees (Bergeron et al. 1995). The LDRTF-TRANSECTS were first established and sampled in 1991, only a few years after the maximum mortality caused by the spruce budworm outbreak had occurred (Morin et al. 1993). This made it possible to identify most of the trees killed during the outbreak since on average 75% of them were still standing or fallen with bark and branches intact (Bergeron et al. 1995). The 1991 inventory tallied standing trees and fallen dead trees with bark and branches intact that were greater than 5 cm DBH. Consequently, by adding the population of dead trees to the population of live trees we estimated the stand basal area and density before the spruce budworm outbreak. Note that considering trees greater than 5 cm DBH lessened the chances of including trees that died due to intense suppression (Bergeron et al. 1995). Likewise, in the absence of spruce budworm, the natural mortality rate, is normally low (MacLean and Ostaff 1989), which also reduced the probability of including dead trees due to natural mortality. Figure 4 illustrates the successional dynamics of the main species from the youngest stands that originated from the fire in 1964 to the oldest stands that originated from fire in 1760, following the spruce budworm outbreak. Moreover, Figure 5 compares the basal area and stem density of balsam fir and spruce as the main host species of spruce budworm prior to and following the outbreak.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 1.**Characteristics of the eight fire areas in LDRTF-TRANSECTS data set in 1991 | | | | | |
| Fire date | Fire area\* (ha) | Stand age (y) | Transect number | Quadrat number | Interval (y) |
| 1760 | >7760 | 231 | 6 | 81 | 37 |
| 1797 | 178 | 194 | 4 | 77 | 26 |
| 1823 | 288 | 168 | 5 | 75 | 24 |
| 1847 | 122 | 144 | 4 | 79 | 23 |
| 1870 | 555 | 121 | 6 | 77 | 46 |
| 1916 | 35 | 75 | 2 | 79 | 28 |
| 1944 | >298 | 47 | 4 | 80 | 30 |
| 1964 | 362 | 26 | 4 | 77 |  |
| **Notes:** The fire area has been extracted from Bergeron (2000) where the extent of fires that occurred in 1760 and 1944 is a minimum estimate since the fires burned a larger area than the investigated area. Intervals are calculated based on the time from one wildfire to the next consecutive wildfire. | | | | | |

|  |
| --- |
| Figure 4.pdf - Adobe Acrobat Reader DC |
| **Figure 4.** Successional dynamics of species composition in post-fire stands presented by LDRTF-TRANSECTS data sampled in 1991. The lines represent the species' mean basal area (a) and mean density (b) following the spruce budworm outbreak. The points show the actual basal area and density of tree species in each post-fire stand |

1. Instrumentation: Compass and metric tape
2. Permit history: Not applicable
3. Legal/organizational requirements: The LDRTF is under a forest management agreement between the University of Quebec in Montreal (UQAM), the University of Quebec in Abitibi-Temiscamingue (UQAT), and the Ministry of Forests, Wildlife and Parks (MFFP) of Quebec.

|  |
| --- |
| Figure 5.pdf - Adobe Acrobat Reader DC |
| **Figure 5.** The changes in the proportions of spruce budworm host species in post-fire stands, induced by the most recent spruce budworm outbreak, presented by LDRTF-TRANSECTS data sampled in 1991. The dashed and solid lines represent the species' mean basal area (a) and mean density (b) prior to and following the spruce budworm outbreak, respectively. The points show the actual basal area and density of tree species in each post-fire stand, prior to and following the outbreak. |

LDRTF-SEEDLING\_PLOTS:

1. Field/laboratory: In each 400-m2 plot (eight plots for eight post-fire stands), the diameter of all trees with DBH greater than 2 cm, alive or dead (standing or fallen), were measured, and trees were identified to species. Dead fallen trees were not recorded in the first census of the plot. Within each plot, trees were tagged, and their Cartesian coordinates were recorded. Starting in 2005, crown class (dominance status of the stem) was recorded for live trees, and decay class (level of breakage or decay) was recorded for dead trees according to Imbeau and Desrochers (2002). The live crown percentage was also recorded on live trees, starting between 1991 and 2001 (depending on the plot), according to Ecological Monitoring and Assessment Network Protocol (Environment Canada 1999, Environment Canada 2004). Stem injuries (e.g., cracks, wounds, animal or fire damage) were also recorded on live trees. In 1998-2002 natural (1N, 2N, 3N, 4N, 5N, 6N, 7N, and 8N) and scarified (1S, 2S, 3S, 4S, 5S, 6S, 7S, and 8S) subplots were sampled three times (throughout the summer season) each year (Figure 3). From 2002, a visit in late May-early June was added to natural subplots to identify the number of seedlings (suckers for aspen) from the previous year that survived the winter, resulting in four visits per year since 2002. Since 2001, only 2S, 4S, 6S, and 8S subplots were scarified each autumn. Within each subplot, all the seedlings and aspen suckers (or a subsample of seedlings when impossible to mark all individuals due to very high seedlings density (number in m2) were individually marked by coloured tape specified for each species (e.g., red: *A. balsamea*, blue: *P. glauca*, green: *T. occidentalis*, yellow: *P. tremuloides* and white: *B. papyrifera*). The number of the visit and the year of germination were recorded on the tape. Figure 6 presents an overview of the species recruitment and survival rate during the survey period.

|  |
| --- |
| Figure 6.pdf - Adobe Acrobat Reader DC |
| **Figure 6.** The seedling (suckers for aspen) recruitment (a) and survival rate (species survival/species recruitment, b) of the main species in LDRTF-SEEDLING\_PLOTS. |

1. Instrumentation: Compass and metric tape
2. Permit history: Not applicable
3. Legal/organizational requirements: The LDRTF is under a forest management agreement between UQAM, UQAT, and MFFP.

LDRTF-HECTARES:

1. Field/laboratory: Each plot was divided into 100-m2 subplots, on which all living and dead trees (standing and fallen) with DBH greater than 5 cm were measured, mapped, and identified to species level. Dead fallen trees were not recorded in the first census of the plot. For mapping, the trees, their distances, without slope correction, from two perpendicular plot boundaries (or from two corners for plots located on the 1916 fire stand) were measured and then converted to the slope-corrected X-Y coordinates. Crown class (dominance status of the stem) and the live crown percentage were recorded for live trees for all censuses, according to the Ecological Monitoring and Assessment Network Protocol (Environment Canada 1999, Environment Canada 2004). The live crown percentage for alive trees and decay class for dead trees were recorded starting in 2004 based on Imbeau and Desrochers (2002). Stem injuries on live trees were also recorded starting in 2004 for the plots in stands originating from the 1760 and 1916 wildfires and on the third census (2009 or 2011) for other plots.
2. Instrumentation: Compass and metric tape
3. Permit history: Not applicable
4. Legal/organizational requirements: The LDRTF is under a forest management agreement between UQAM, UQAT, and MFFP.

## **C. Data limitations and potential enhancements**

In 2019, LDRTF-SEEDLING\_PLOTS were enlarged to 80 m × 80 m, to observe the seed recruitments from outside the original plots.

# **CLASS III. Data set status and accessibility**

## **A. Status**

**1. Latest update:** August 2020

**2. Latest archive date:** August 2020

**3. Metadata status:** Last updated August 2020, the version published

**4. Data verification:** All records for all three subsets of data have been quality controlled andpresented in a uniform format.

## **B. Accessibility**

**1. Storage location:** Dryad, DOI: [https://doi.org/10.5061/dryad.tqjq2bvwz]

**2. Contact persons:** Philippe Marchand (philippe.marchand@uqat.ca), University of Québec in Abitibi-Témiscamingue, 445 boul. de l'Université, Rouyn-Noranda, QC J9X 5E4, Canada and Danielle Charron, ([charron.danielle@uqam.ca](mailto:charron.danielle@uqam.ca)), Department of Biological Sciences, University of Quebec in Montreal, Montréal, QC H3C 3P8, Canada.

**3. Copyright restrictions:** None

**4. Proprietary restrictions:** Please cite this data paper when the data are used in publications. We also request that researchers and teachers inform us of how they are using the data. We are open to collaborate in developing or co-authoring relevant research projects based on this dataset.

**5. Costs:** None

# **CLASS IV. Data structural descriptors**

## **A. Data Set File**

**1. Identity:** DataS1.zip

**2. Size:** 475 KB when zipped and 3.05 MB when unzipped, includes 20 CSV files (Table 2)

**3. Format and storage mode:** Comma-separated values (.csv)

**4. Header information:** See variable information in section B.

**5. Alphanumeric attributes:** Mixed

**6. Special characters/fields:** None

**7. Authentication producers:** None

## **B. Variable information**

For differentiation among the three LDRTF data sets provided, when applicable we used the “S” prefix for variables in LDRTF-SEEDLING\_PLOTS and “H” prefix for variables in LDRTF-HECTARES data. Variables in LDRTF-TRANSECTS data do not get any specific prefix. The column descriptions for the LDRTF dataset can be found in Table 2.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 2.** The columns description for the LDRTF dataset | | | | | |
| **LDTRF-TRANSECTS** | | | | | |
| Plots: transect\_plots.csv | | | | | |
| Variable | Data type | | Description | | |
| plot\_id | String | | 12-character plot ID formed by transect ID and distance along the transect | | |
| fire\_year | Integer | | Year of last fire in the stand | | |
| transect | String | | Transect ID formed by fire year and transect number | | |
| long | Real | | Longitude of the plot (decimal degrees) | | |
| lat | Real | | Latitude of the plot (decimal degrees) | | |
|  |  | |  | | |
| Measurements: transect\_meas.csv | | | | | |
| Variable | Data type | | Description | | |
| plot\_id | String | | Plot ID (from transect\_plots table) | | |
| year | Integer | | Year of measurement | | |
| species\_id | String | | Species ID (from code\_species table) | | |
| status\_id | String | | Status of the stem, i.e. alive or dead with modifier (from code\_status table) | | |
| dbh\_class | Real | | Diameter at breast height (DBH) class, denoted by midpoint of class (in cm), i.e. 0.5 for seedlings (DBH <1cm), 2.5 for saplings (DBH <5cm), 7.5 for trees 5-10cm, and so on by 5-cm increments. | | |
| count | Integer | | Number of items with this species, status, and DBH class | | |
|  |  | |  | | |
| **LDTRF-SEEDLINGS** | | | | | |
| Plots: seedling\_plots.csv | | | | | |
| Variable | Data type | | Description | | |
| plot\_id | String | | Plot ID (fire year preceded by “S”) | | |
| fire\_year | Integer | | Year of last fire in the stand | | |
| long | Real | | Longitude of the plot (decimal degrees) | | |
| lat | Real | | Latitude of the plot (decimal degrees) | | |
|  |  | |  | | |
| Stems in plots: seedling\_stems.csv | | | | | |
| Variable | Data type | | Description | | |
| stem\_id | String | | Stem ID, formed by plot ID and stem number | | |
| plot\_id | String | | Plot ID (from seedling\_plots table) | | |
| species\_id | String | | Species ID (from code\_species table) | | |
| x | Real | | x-coordinate of the stem in the plot | | |
| y | Real | | y-coordinate of the stem in the plot | | |
|  |  | |  | | |
| Stem measurements in plots: seedling\_stem\_meas.csv | | | | | |
| Variable | | Data type | | | Description |
| meas\_id | | String | | | Measurement ID numbered in sequence with prefix “SM” |
| stem\_id | | String | | | Stem ID (from seedling\_stems table) |
| year | | Integer | | | Year of measurement |
| dbh | | Real | | | Diameter at breast height in cm |
| status\_id | | String | | | Status of the stem, i.e. alive or dead with modifier (from code\_status table) |
| crown\_class | | String | | | Vertical dominance class of crown (from code\_crown table) |
| live\_crown\_class | | String | | | Live crown percentage class (from code\_live\_crown table) |
| decay\_class | | String | | | Decay class for dead trees (from code\_decay table) |
|  | |  | | |  |
| Stem injuries: seedling\_stem\_health.csv | | | | | |
| Variable | | Data type | | Description | |
| meas\_id | | String | | Measurement ID (from seedling\_stem\_meas table) | |
| health\_id | | String | | Injury type (from code\_health table) | |
| location\_id | | String | | Injury location on the tree (from code\_location table) | |
| notes | | String | | Comments on nature of the injury | |
|  | |  | |  | |
| Seedling subplots: seedling\_subplots.csv | | | | | |
| Variable | | Data type | | Description | |
| subplot\_id | | String | | 8-character string formed by plot\_id and subplot number | |
| plot\_id | | String | | Plot ID (from seedling\_plots table) | |
| treatment | | String | | Whether subplot was scarified or not (“natural”) | |
|  | |  | |  | |
| Seedling census dates: seedling\_census\_dates.csv | | | | | |
| Variable | | Data type | | Description | |
| plot\_id | | String | | Plot ID (from seedling\_plots table) | |
| year | | Integer | | Year of the seedling census | |
| census\_no | | Integer | | Number of censuses within the year (1 to 4, with earliest census (1) absent before 2002) | |
| date | | String | | The exact date of the seedling census for subplots of that plot for that year (YYYY-MM-DD format) | |
|  | |  | |  | |
| Seedling census counts: seedling\_census\_counts.csv | | | | | |
| Variable | | Data type | | Description | |
| subplot\_id | | String | | 8-character string formed by plot\_id and subplot number | |
| species\_id | | String | | Species of seedlings (from code\_species table) | |
| first\_year | | Integer | | Year where that group of seedlings was first observed | |
| first\_census | | Integer | | Census number where that group of seedlings was first observed | |
| current\_year | | Integer | | Year for current observations | |
| current\_census | | Integer | | Census number for current observations | |
| count | | Integer | | Count of live seedlings in a group for current census | |
|  | |  | |  | |
| **LDTRF-HECTARES** | | | | | |
| Plots: hectare\_plots.csv | | | | | |
| Variable | Data type | | Description | | |
| plot\_id | String | | Plot ID (fire year preceded by “H”) | | |
| fire\_year | Integer | | Year of last fire in the stand | | |
| long | Real | | Longitude of the plot (decimal degrees) | | |
| lat | Real | | Latitude of the plot (decimal degrees) | | |
|  |  | |  | | |
| Stems: hectare\_stems.csv | | | | | |
| Variable | Data type | | Description | | |
| stem\_id | String | | Stem ID, formed by plot ID and stem number | | |
| plot\_id | String | | Plot ID (from hectare\_plots table) | | |
| species\_id | String | | Species ID (from code\_species table) | | |
| x | Real | | x-coordinate of the stem in the plot | | |
| y | Real | | y-coordinate of the stem in the plot | | |
|  |  | |  | | |
| Stem measurements: hectare\_stem\_meas.csv | | | | | |
| Variable | | Data type | | | Description |
| meas\_id | | String | | | Measurement ID numbered in sequence with prefix “HM” |
| stem\_id | | String | | | Stem ID (from hectare\_stems table) |
| year | | Integer | | | Year of measurement |
| dbh | | Real | | | Diameter at breast height in cm |
| status\_id | | String | | | Status of the stem, i.e. alive or dead with modifier (from code\_status table) |
| crown\_class | | String | | | Vertical dominance class of crown (from code\_crown table) |
| live\_crown\_class | | String | | | Live crown percentage class (from code\_live\_crown table) |
| decay\_class | | String | | | Decay class for dead trees (from code\_decay table) |
|  | |  | | |  |
| Stem injuries: hectare\_stem\_health.csv | | | | | |
| Variable | | Data type | | Description | |
| meas\_id | | String | | Measurement ID (from hectare\_stem\_meas table) | |
| health\_id | | String | | Injury type (from code\_health table) | |
| location\_id | | String | | Injury location on the tree (from code\_location table) | |
| notes | | String | | Comments on nature of the injury | |

**CODE DEFINITION TABLES**

Seven tables (code\_crown.csv, code\_decay.csv, code\_health.csv, code\_live\_crown.csv, code\_location.csv, code\_species.csv, and code\_status.csv) define the codes used in the preceding data tables. Each code table has two columns (code and description).

## **C. Data anomalies**

If no information is available for a given record, this is indicated as “NA”.

# **CLASS V. Supplemental descriptors**

## **A. Data acquisition**

**1. Data forms or acquisition methods:** No specific or standard form/ method is used, and the data form or acquisition method can vary from one fieldwork to another, depending on the objectives of fieldwork and data collection.

**2. Location of completed data forms:** Lake Duparquet Research and Teaching Station

**3. Data entry/verification procedures:** Returning to the field after data entry to verify missing data, errors, etc.

**B. Quality assurance/quality control procedures**

For each field season, different teams and people may work to collect the data, however, to ensure the accuracy of data collection and measurements the same technician explained and supervised the procedures of the field experiments and data entry.

## **F. Publications and results**

Since the establishment of the data, several studies and projects have used the LDRTF data directly or indirectly (i.e., using the information to design new observational studies at the site). Bergeron and Charron (1994), Paré and Bergeron (1995), Bergeron et al. (1995), Bergeron and Leduc (1998) Kneeshaw and Bergeron (1998), Kneeshaw et al. (1998), Messier et al. (1998), Kneeshaw and Bergeron (1999), Bergeron (2000), Hély et al.*a* (2000*a*), Hély et al.*b* (2000*b*), Hély et al. (2001), Bergeron et al. (2002), Namroud et al.*b* (2005*b*), Park et al. (2005), Nlungu-Kweta et al. (2014), Bose et al. (2015), Latutrie et al. (2015), Aussenac et al. (2017), Nlungu-Kweta et al. (2017), Aussenac et al. (2019), Drobyshev et al. (2019), Latutrie et al. (2019), Maleki et al. (2020), (Maleki et al. 2021), and Leduc et al. (2020) are some of the main studies that used the LDRTF data directly. Bergeron and Dubuc (1989), Morin et al. (1993), DeGrandpré et al. (1993), Paré et al. (1993), Lavertu et al. (1994), Brais et al. (1995), Kneeshaw and Bergeron (1996), Paré and Bergeron (1996), Bergeron and Harvey (1997), DeGrandpré and Bergeron (1997), Simard et al. (1998), Légaré et al. (2001), Légaré et al. (2002), Kernaghan et al. (2003), Simard et al. (2003), D'Aoust et al. (2004), Namroud et al.*a* (2005*a*), Huang et al. (2008), Huang et al. (2010), Beaudet et al. (2011), DeGrandpré et al. (2011), Moulinier et al. (2011), Xu et al. (2012), Moulinier et al. (2013), Bergeron et al. (2014), and Xu et al. (2018) are some of the studies that used the LDRTF data indirectly. This dataset also served as the basis for the ecosystem forest management plan at the LDRTF.

# **ACKNOWLEDGMENTS**

We are grateful to the financial support provided by the Natural Sciences and Engineering Research Council of Canada (NSERC); Quebec’s Ministry of Science, Technology, and Innovation; the Quebec Research Fund - Nature and Technologies (FRQNT); Quebec’s Ministry of Forests, Wildlife, and Parks (MFFP); the Federal Government Green Plan program; Natural Resources Canada, the CRSNG-UQAT-UQAM Industrial Chair in Sustainable Forest Management (Chaire AFD); the Lake Duparquet Research and Teaching Forest (FERLD); Norbord Inc.; Rayonier Advanced Materials(formerly Tembec); and the MITACS not-for-profit research and training organization. We are thankful among many to Daniel Lesieur for database design and management, France Conciatori, Francois Tetreault, and numerous student field assistants, in particular. We also thank Suzanne Brais and Brian Harvey for acknowledging that this dataset could be used as a guideline for ecosystem-based forest management.

# **LITERATURE CITED IN METADATA**

Aubin, I., C. Messier, and D. Kneeshaw. 2005. Population structure and growth acclimation of mountain maple along a successional gradient in the southern boreal forest. Écoscience **12:**540–548.

Aussenac, R., Y. Bergeron, C. Ghotsa Mekontchou, D. Gravel, K. Pilch, and I. Drobyshev. 2017. Intraspecific variability in growth response to environmental fluctuations modulates the stabilizing effect of species diversity on forest growth. Journal of Ecology **105:**1010–1020.

Aussenac, R., Y. Bergeron, D. Gravel, and I. Drobyshev. 2019. Interactions among trees: A key element in the stabilising effect of species diversity on forest growth. Functional Ecology **33:**360–367.

Beaudet, M., B. D. Harvey, C. Messier, K. D. Coates, J. Poulin, D. D. Kneeshaw, S. Brais, and Y. Bergeron. 2011. Managing understory light conditions in boreal mixedwoods through variation in the intensity and spatial pattern of harvest: A modelling approach. Forest Ecology and Management **261:**84–94.

Bergeron, Y. 1991. The Influence of Island and Mainland Lakeshore Landscapes on Boreal Forest Fire Regimes. Ecology **72:**1980–1992.

Bergeron, Y. 2000. Species and Stand Dynamics in the Mixed Woods of Quebec's Southern Boreal Forest. Ecology **81:**1500–1516.

Bergeron, Y., and D. Charron. 1994. Postfire stand dynamics in a southern boreal forest (Québec): a dendroecological approach. **1:**173–184.

Bergeron, Y., H. Y. Chen, N. C. Kenkel, A. L. Leduc, and S. E. Macdonald. 2014. Boreal mixedwood stand dynamics: ecological processes underlying multiple pathways. The Forestry Chronicle **90:**202–213.

Bergeron, Y., B. Denneler, D. Charron, and M.-P. Girardin. 2002. Using dendrochronology to reconstruct disturbance and forest dynamics around Lake Duparquet, northwestern Quebec. Dendrochronologia **20:**175–189.

Bergeron, Y., and M. Dubuc. 1989. Succession in the southern part of the Canadian boreal forest. Vegetatio **79:**51–63.

Bergeron, Y., S. Gauthier, V. Kafka, P. Lefort, and D. Lesieur. 2001. Natural fire frequency for the eastern Canadian boreal forest: consequences for sustainable forestry. Canadian Journal of Forest Research **31:**384–391.

Bergeron, Y., and B. Harvey. 1997. Basing silviculture on natural ecosystem dynamics: an approach applied to the southern boreal mixedwood forest of Quebec. Forest Ecology and Management **92:**235–242.

Bergeron, Y., and A. Leduc. 1998. Relationships between change in fire frequency and mortality due to spruce budworm outbreak in the southeastern Canadian boreal forest. Journal of Vegetation Science **9:**492–500.

Bergeron, Y., A. Leduc, C. Joyal, and H. Morin. 1995. Balsam fir mortality following the last spruce budworm outbreak in northwestern Quebec. Canadian Journal of Forest Research **25:**1375–1384.

Bose, A. K., B. D. Harvey, K. D. Coates, S. Brais, and Y. Bergeron. 2015. Modelling stand development after partial harvesting in boreal mixedwoods of eastern Canada. Ecological Modelling **300:**123–136.

Brais, S., C. Camiré, Y. Bergeron, and D. Paré. 1995. Changes in nutrient availability and forest floor characteristics in relation to stand age and forest composition in the southern part of the boreal forest of northwestern Quebec. Forest Ecology and Management **76:**181–189.

Canada Soil Survey Committee. 1998. Canadian System of Soil Classification, 3rd ed.Publ. 1646. Agriculture Canada, Ottawa, Canada.

D'Aoust, V., D. Kneeshaw, and Y. Bergeron. 2004. Characterization of canopy openness before and after a spruce budworm outbreak in the southern boreal forest. Canadian Journal of Forest Research **34:**339–352.

DeGrandpré, L., and Y. Bergeron. 1997. Diversity and Stability of Understorey Communities Following Disturbance in the Southern Boreal Forest. Journal of Ecology **85:**777.

DeGrandpré, L., D. Boucher, Y. Bergeron, and D. Gagnon. 2011. Effects of small canopy gaps on boreal mixedwood understory vegetation dynamics. Community Ecology **12:**67–77.

DeGrandpré, L., D. Gagnon, and Y. Bergeron. 1993. Changes in the understory of Canadian southern boreal forest after fire. Journal of Vegetation Science **4:**803–810.

DeGrandpré, L. de, J. Morissette, and S. Gauthier. 2000. Long-term post-fire changes in the northeastern boreal forest of Quebec. Journal of Vegetation Science **11:**791–800.

Drobyshev, I., S. Picq, E. Ganivet, F. Tremblay, and Y. Bergeron. 2019. Decline in the strength of genetic controls on aspen environmental responses from seasonal to century‐long phenomena. Ecosphere **10:**137.

Environment Canada. 1999. Protocoles de suivi de la biodiversité végétale terrestre. Collection des publications hors-série du RESE.

Environment Canada. 2004. Protocoles et normes de surveillance RESE. Santé des arbres. Document modifié mars 2004.

Environment Canada. 2017. Canadian climate normals 1981–2010. Retrieved from http://www.climate.weather.gc.ca/climate\_normals/index\_e.html.

Harvey, B. D., and S. Brais. 2007. Partial cutting as an analogue to stem exclusion and dieback in trembling aspen (*Populus tremuloides)* dominated boreal mixedwoods: implications for deadwood dynamics. This article is one of a selection of papers published in the Special Forum IUFRO 1.05 Uneven-Aged Silvicultural Research Group Conference on Natural Disturbance-Based Silviculture: Managing for Complexity. Canadian Journal of Forest Research **37:**1525–1533.

Hély, C., Y. Bergeron, and M. D. Flannigan. 2000*a.* Coarse woody debris in the southeastern Canadian boreal forest: composition and load variations in relation to stand replacement. Canadian Journal of Forest Research **30:**674–687.

Hély, C., Y. Bergeron, and M. D. Flannigan. 2000*b.* Effects of stand composition on fire hazard in mixed-wood Canadian boreal forest. Journal of Vegetation Science **11:**813–824.

Hély, C., M. Flannigan, Y. Bergeron, and D. McRae. 2001. Role of vegetation and weather on fire behavior in the Canadian mixedwood boreal forest using two fire behavior prediction systems. Canadian Journal of Forest Research **31:**430–441.

Huang, J.-G., J. Tardif, Y. Bergeron, B. Denneler, F. Berninger, and M.-P. Girardin. 2010. Radial growth response of four dominant boreal tree species to climate along a latitudinal gradient in the eastern Canadian boreal forest. Global Change Biology **16:**711–731.

Huang, J.-G., J. Tardif, B. Denneler, Y. Bergeron, and F. Berninger. 2008. Tree-ring evidence extends the historic northern range limit of severe defoliation by insects in the aspen stands of western Quebec, Canada. Canadian Journal of Forest Research **38:**2535–2544.

Imbeau, L., and A. Desrochers. 2002. Foraging Ecology and Use of Drumming Trees by Three-Toed Woodpeckers. The Journal of Wildlife Management **66:**222.

Kernaghan, G., P. Widden, Y. Bergeron, S. Legare, and D. Pare. 2003. Biotic and abiotic factors affecting ectomycorrhizal diversity in boreal mixed-woods. Oikos **102:**497–504.

Kneeshaw, D., Y. Bergeron, and L. de Grandpré. 1998. Early response of Abies balsamea seedlings to artificially created openings. Journal of Vegetation Science **9:**543–550.

Kneeshaw, D. D., and Y. Bergeron. 1996. Ecological factors affecting the abondance of advance regeneration in Quebec's southwestern boreal forest. Canadian Journal of Forest Research **26:**888–898.

Kneeshaw, D. D., and Y. Bergeron. 1998. Canopy Gap Characteristics and Tree Replacement in the Southeastern Boreal Forest. Ecology **79:**783–794.

Kneeshaw, D. D., and Y. Bergeron. 1999. Spatial and temporal patterns of seedling and sapling recruitment within canopy gaps caused by spruce budworm. Écoscience **6:**214–222.

Latutrie, M., P. Mérian, S. Picq, Y. Bergeron, and F. Tremblay. 2015. The effects of genetic diversity, climate and defoliation events on trembling aspen growth performance across Canada. Tree Genetics & Genomes **11**.

Latutrie, M., E. G. Tóth, Y. Bergeron, and F. Tremblay. 2019. Novel insights into the genetic diversity and clonal structure of natural trembling aspen (Populus tremuloides Michx.) populations: A transcontinental study. Journal of Biogeography **46:**1124–1137.

Lavertu, D., Y. Mauffette, and Y. Bergeron. 1994. Suckering success of aspen (Populus tremuloides Michx.) in relation to stand age and soil disturbance. **5:**561–568.

Leduc, A., and K. D. Coates. 2013. Parameterization changes to the lac Duparquet SORTIE-ND model. (a report carried out as a part of Master thesis).

Leduc, A., A. Leduc, D. Kneeshaw, K. Maleki, and Y. Bergeron. 2020. Advancing and reversing succession as a function of time since fire and insect outbreaks: An 18yr in situ re‐measurement of changes in forest composition. Journal of Vegetation Science. doi:10.1111/jvs.12974.

Légaré, S., Y. Bergeron, A. Leduc, and D. Paré. 2001. Comparison of the understory vegetation in boreal forest types of southwest Quebec. Canadian Journal of Botany **79:**1019–1027.

Légaré, S., Y. Bergeron, and D. Paré. 2002. Influence of forest composition on understory cover in boreal mixedwood forests of western Quebec. Silva Fennica **36**.

MacLean, D. A., and D. P. Ostaff. 1989. Patterns of balsam fir mortality caused by an uncontrolled spruce budworm outbreak. Canadian Journal of Forest Research **19:**1087–1095.

Maleki, K., M. A. Gueye, B. Lafleur, A. Leduc, and Y. Bergeron. 2020. Modelling Post-Disturbance Successional Dynamics of the Canadian Boreal Mixedwoods. Forests **11:**3.

Maleki, K., B. Lafleur, A. Leduc, and Y. Bergeron. 2021. Modelling the influence of different harvesting methods on forest dynamics in the boreal mixedwoods of western Quebec, Canada. Forest Ecology and Management **479:**118545.

MDDELCC. 2017. Rapport sur l’interdiction des transferts d’eau hors Québec, En application de l’article 31.108 de la Loi sur la qualité de l’environnement, http://www.mddelcc.gouv.qc.ca/eau/protection/index.htm.

Messier, C., S. Parent, and Y. Bergeron. 1998. Effects of overstory and understory vegetation on the understory light environment in mixed boreal forests. Journal of Vegetation Science **9:**511–520.

Morin, H., D. Laprise, and Y. Bergeron. 1993. Chronology of spruce budworm outbreaks near Lake Duparquet, Abitibi region, Quebec. Canadian Journal of Forest Research **23:**1497–1506.

Moulinier, J., F. Lorenzetti, and Y. Bergeron. 2011. Gap dynamics in aspen stands of the Clay Belt of northwestern Quebec following a forest tent caterpillar outbreak. Canadian Journal of Forest Research **41:**1606–1617.

Moulinier, J., F. Lorenzetti, and Y. Bergeron. 2013. Effects of a forest tent caterpillar outbreak on the dynamics of mixedwood boreal forests of eastern Canada. Écoscience **20:**182–193.

Namroud, M.-C., A. Park, F. Tremblay, and Y. Bergeron. 2005*a.* Clonal and spatial genetic structures of aspen (Populus tremuloides Michx.). Molecular Ecology **14:**2969–2980.

Namroud, M.-C., F. Tremblay, and Y. Bergeron. 2005*b.* Temporal variation in quaking aspen (Populus tremuloides) genetic and clonal structures in the mixedwood boreal forest of eastern Canada. Écoscience **12:**82–91.

Nlungu-Kweta, P., A. Leduc, and Y. Bergeron. 2014. Conifer Recruitment in Trembling Aspen (Populus Tremuloides Michx.) Stands along an East-West Gradient in the Boreal Mixedwoods of Canada. Forests **5:**2905–2928.

Nlungu-Kweta, P., A. Leduc, and Y. Bergeron. 2017. Climate and disturbance regime effects on aspen (Populus tremuloides Michx.) stand structure and composition along an east–west transect in Canada's boreal forest. Forestry **90:**70–81.

Paré, D., and Y. Bergeron. 1995. Above-Ground Biomass Accumulation along a 230-Year Chronosequence in the Southern Portion of the Canadian Boreal Forest. Journal of Ecology **83:**1001.

Paré, D., and Y. Bergeron. 1996. Effect of colonizing tree species on soil nutrient availability in a clay soil of the boreal mixedwood. Canadian Journal of Forest Research **26:**1022–1031.

Paré, D., Y. Bergeron, and C. Camiré. 1993. Changes in the forest floor of Canadian southern boreal forest after disturbance. Journal of Vegetation Science **4:**811–818.

Park, A., D. Kneeshaw, Y. Bergeron, and A. Leduc. 2005. Spatial relationships and tree species associations across a 236-year boreal mixedwood chronosequence. Canadian Journal of Forest Research **35:**750–761.

Poulin, J., and C. Messier. 2008. Rapport de paramétrisation du modèle de simulationde la dynamique forestière SORTIE-ND pour la forêt boréale et sub-boréale del’ouest du Québec., Centre d’Étude de la forêt, Université du Québec à Montréal.

Poulin, J., C. Messier, M. Papaik, M. Beaudet, and D. K. Coates. 2007. Rapport de paramétrisation du modele de simulation de la dynamique forestiere SORTIE-ND pour la forêt boréale et sub-boréale de l’ouest du Québec.

Saucier, J. P., J. F. Bergeron, P. Grondin, and A. Robitaille. 1998. Les régions écologiquesdu Québec méridional (3iéme version): Un des éléments du systéme hiérar-chique de classification écologique du territoire mis au point par le ministére desRessources naturelles du Québec, L’Aubelle, February–March 1998.

Saucier, J.-P., P. Grondin, A. Robitaille, and J.-F. Bergeron. 2003. Vegetation zones and bioclimatic domains in Québec. Direction des Inventaires Forestiers, Ministere des Ressources naturelles du Québec, Québec, Québec, Canada:1–2.

Simard, M.-J., Y. Bergeron, and L. Sirois. 1998. Conifer seedling recruitment in a southeastern Canadian boreal forest: the importance of substrate. Journal of Vegetation Science **9:**575–582.

Simard, M.-J., Y. Bergeron, and L. Sirois. 2003. Substrate and litterfall effects on conifer seedling survivorship in southern boreal stands of Canada. Canadian Journal of Forest Research **33:**672–681.

Veillette, J. J. 1994. Evolution and paleohydrology of glacial Lakes Barlow and Ojibway. Quaternary Science Reviews **13:**945–971.

Xu, H., F. Tremblay, and Y. Bergeron. 2018. Importance of landscape features and fire refuges on genetic diversity of Thuya occidentalis L., in boreal fire dominated landscapes. Conservation Genetics **19:**1231–1241.

Xu, H., F. Tremblay, Y. Bergeron, V. Paul, and C. Chen. 2012. Genetic consequences of fragmentation in “arborvitae,” eastern white cedar (Thuja occidentalis L.), toward the northern limit of its distribution range. Ecology and evolution **2:**2506–2520.