Université du Québec à Rimouski May 19, 2015

Difficult migration of temperate tree species in boreal forest under climate change?

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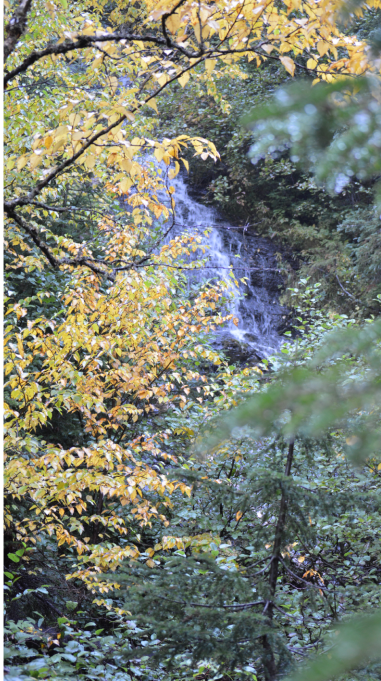
Isabelle Boulangeat and Dominique Gravel

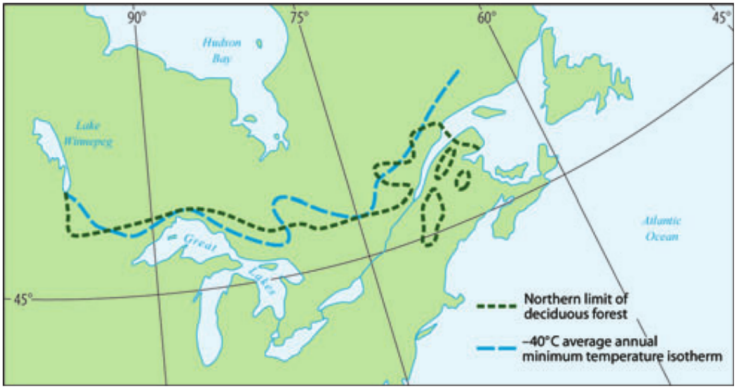
QUICCY FOR
Quantifying and mapping the impact of climate change on forest productivity in Eastern Canada



The surface of the boreal-temperate forests ecotone is **expected to shift over the next 100 years**.

Goldblum and Rig, 2010

1. The location of this ecotone is **responsive to climate**.



Goldblum and Rig, 2010

2. Several temperate forest species are predicted to **shift northward** under climate change

Sugar maple

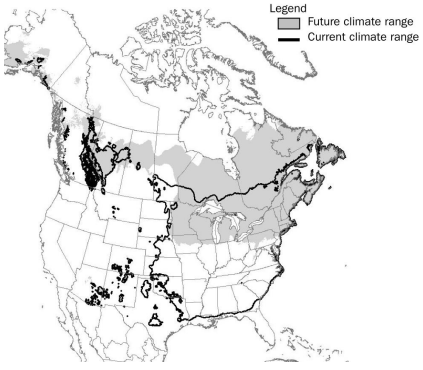
Red oak

Yellow birch

American ash

McKenney *et al*, 2007; Woodall *et al*, 2008; Iverson and Prasad, 2002. Web illustrations

2. Several temperate forest species are predicted to **shift northward** under climate change



Future climate enveloppe of Sugar maple (2071-2100)

McKenney *et al*, 2007

Forest have:

1. Limited dispersions
2. Slow population dynamics
3. Interspecific competition

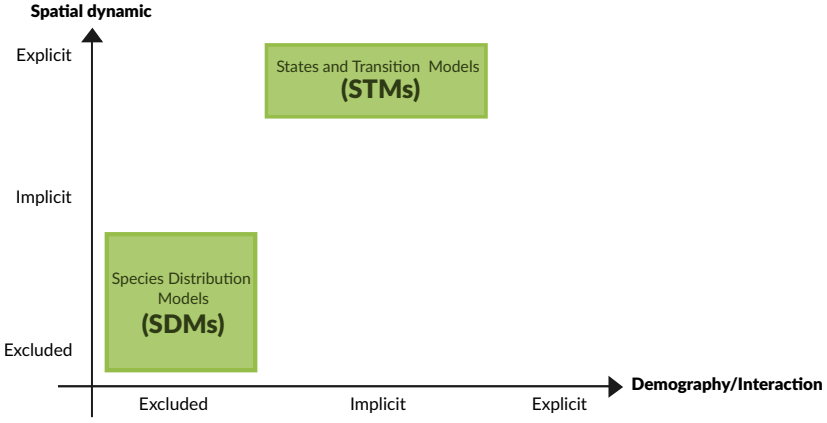
Travis *et al*, 2013

Forest have:

1. Limited dispersions
2. Slow population dynamics
3. Interspecific competition

These components will be affected by future climate

Travis *et al*, 2013



Scheller and Mladenoff *et al*, 2006; Kriticos *et al*, 2013

Study objective

Main objective: Assess range shift and migration rates of the temperate forest community toward boreal forest under climate change.

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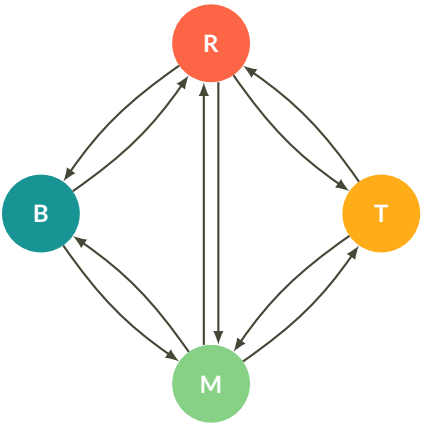
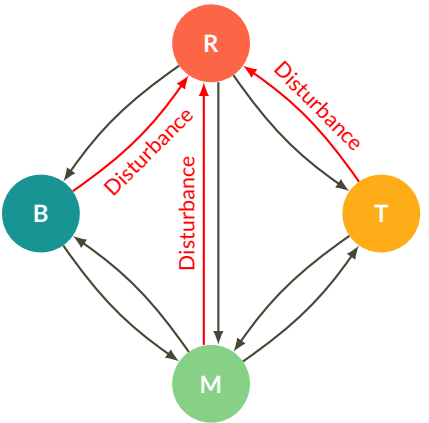
Why?

- Predict the future distribution of temperate species community in Quebec
- Improve and adapt our forests management practices under climate change



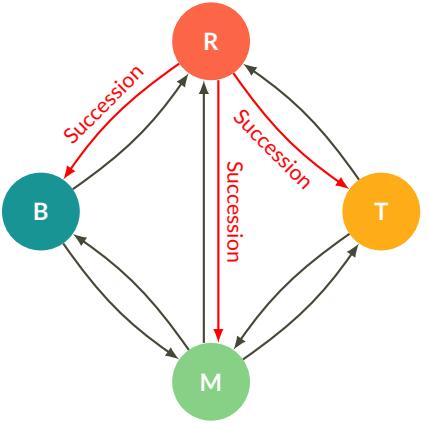
Model Description

- Lanscape scale
- **4 States:**
  - **T**, Temperate
  - **B**, Boreal
  - **M**, Mixed
  - **R**, corresponds to a post-disturbance
- Spatially explicit and stochastic model



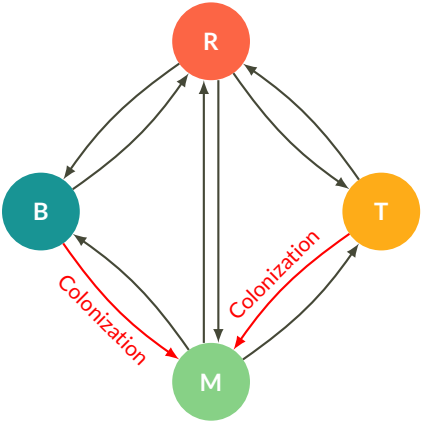
Ecological processes:

- Disturbance



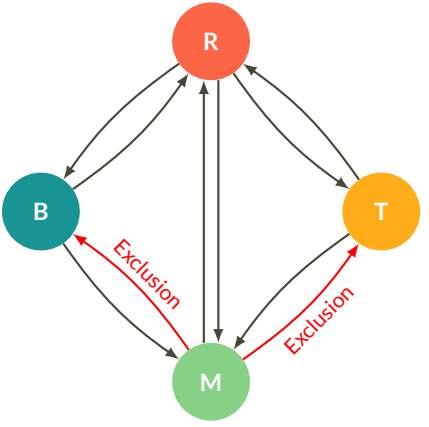
Ecological processes:

- Disturbance
- Succession



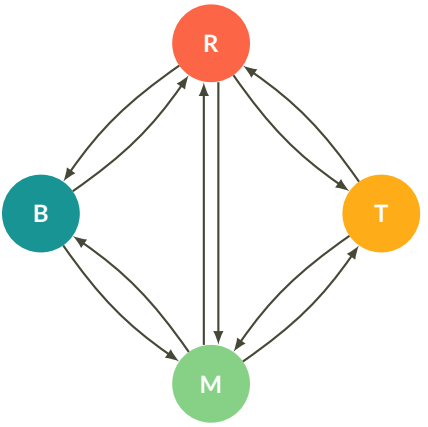
Ecological processes:

- Disturbance
- Succession
- Colonization



Ecological processes:

- Disturbance
- Succession
- Colonization
- Competitive exclusion

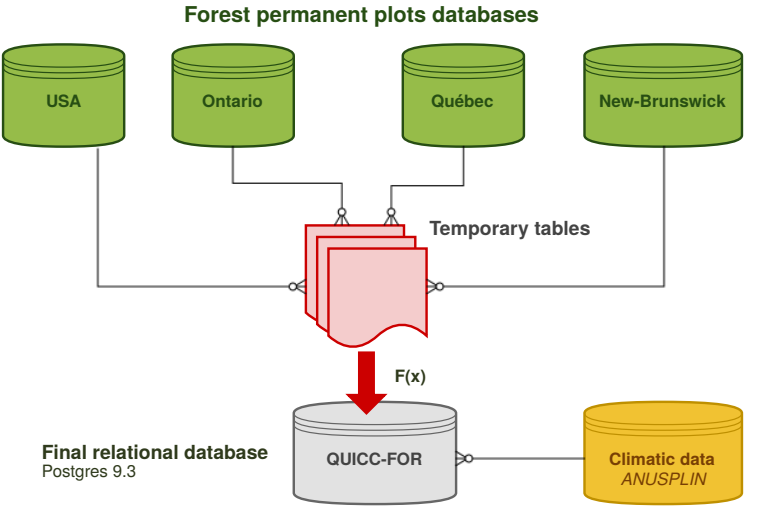


Ecological processes:

- Disturbance
- Succession
- Colonization
- Competitive exclusion

Each probability depends on:

- Proportion of states available in the neighborhood
- Local climatic conditions (Precipitation, Temperature)


Forest permanent plots databases
USA
Ontario
Québec
New-Brunswick
Temporary tables
F(x)
Final relational database
Postgres 9.3
QUICC-FOR
Climatic data
ANUSPLIN

1. **Classify state of each plot**
    - Plot remeasured
    - Transition observed between remeasurements

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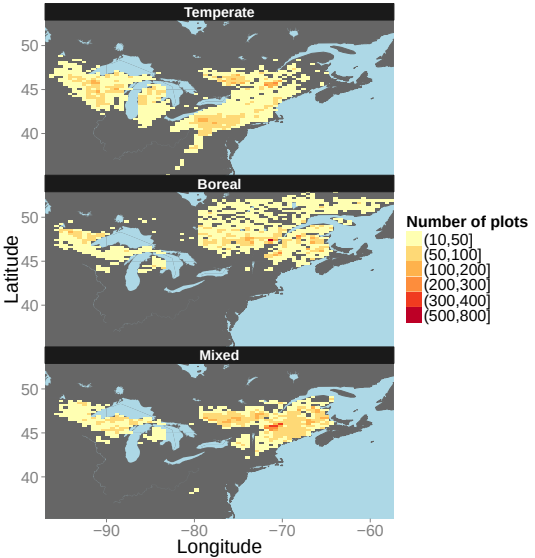
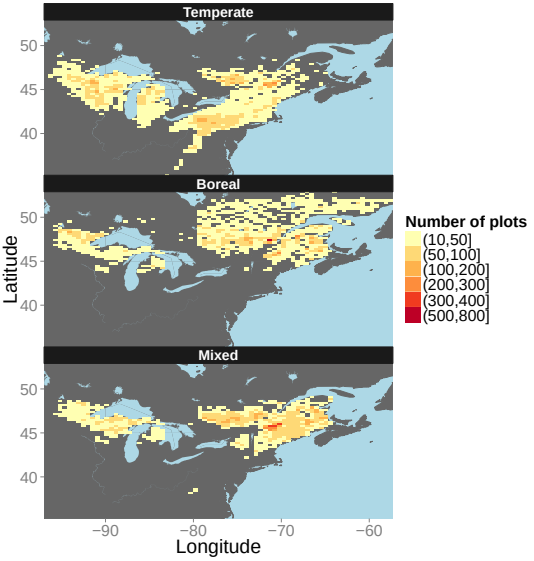
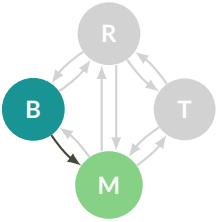
   - Plot remeasured
   - Transition observed between remeasurements

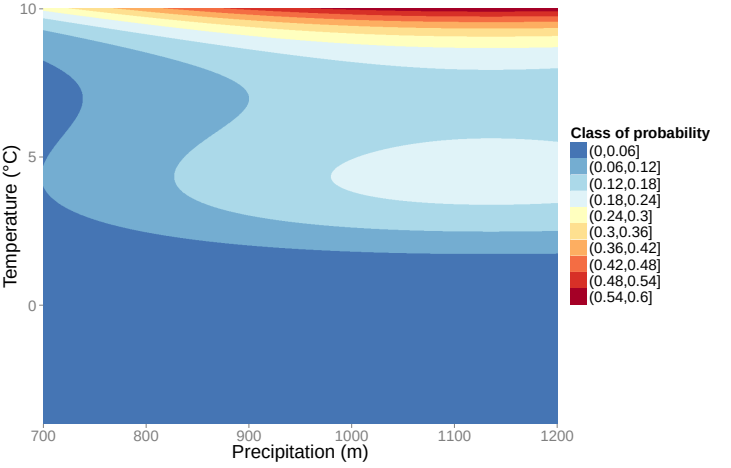


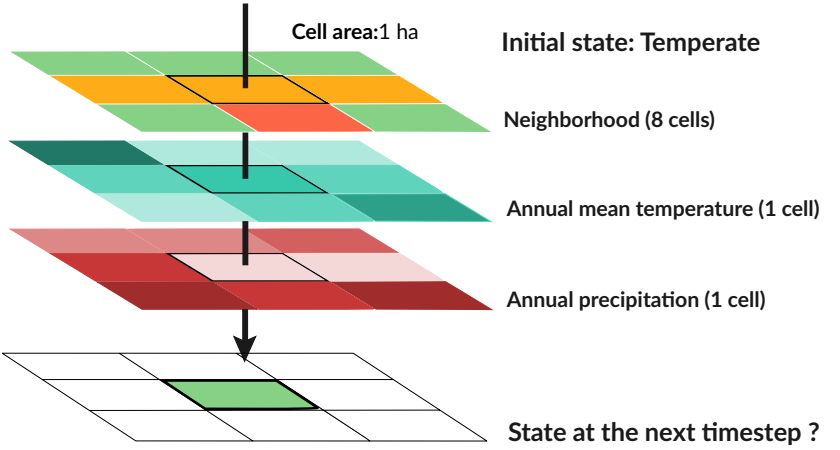
1. **Classify state of each plot**
   - Plot remeasured
   - Transition observed between remeasurements
2. **Compute state transition probabilities** based on the actual climate and neighbors plot states.



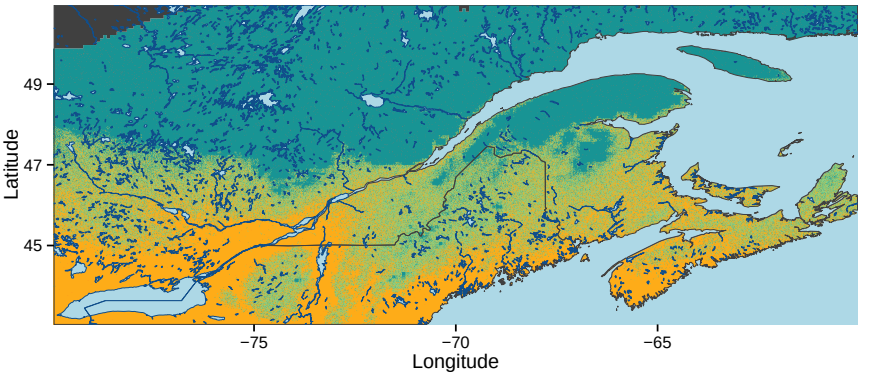
CALIBRATION TRANSITION PROBABILITIES OVER CLIMATIC GRADIENTS

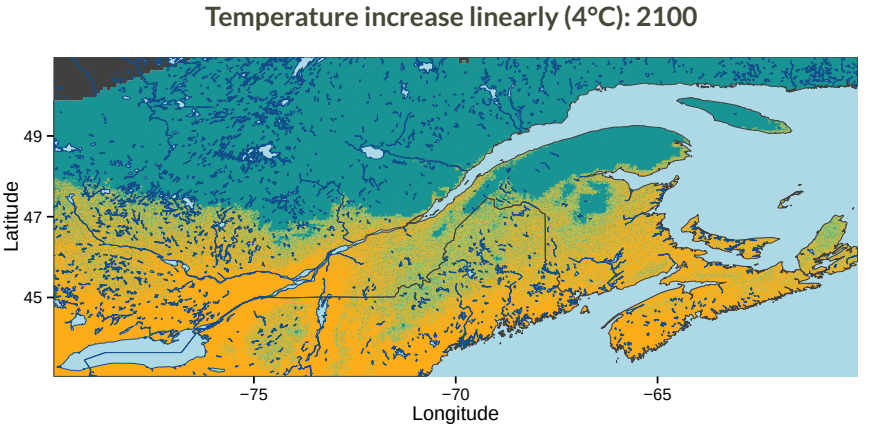


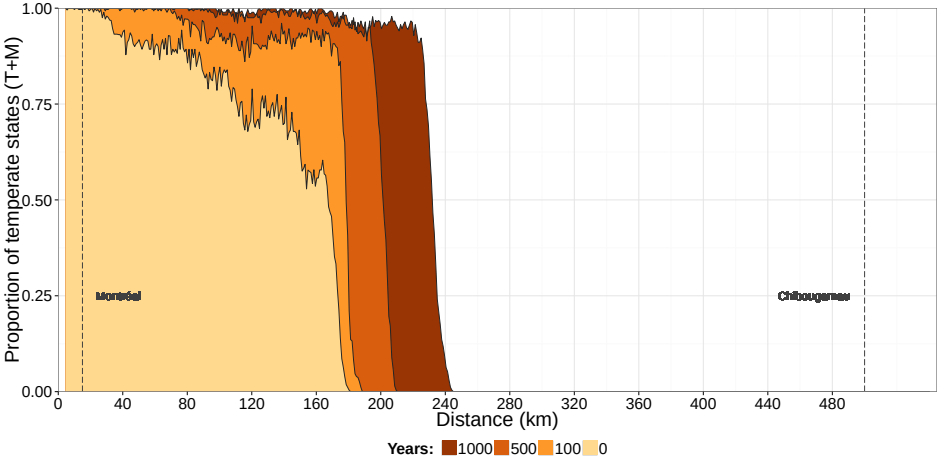



Cell area:1 ha
Initial state: Temperate
Neighborhood (8 cells)
Annual mean temperature (1 cell)
Annual precipitation (1 cell)
State at the next timestep ?

Current states distributions predicted on climatology: 1970-2000




Temperature increase linearly (4°C): 2100
Latitude
49
47
45
−75
−70
−65
Longitude
State
B
M
R
T


1.00
0.75
0.50
0.25
0.00
Proportion of temperate states (T+M)
Montréal
Chibougamau
0
40
80
120
160
200
240
280
320
360
400
440
480
Distance (km)
Years: 1000 500 100 0

Summary

1. Spatial dynamique, demography and species interactions constraint temperate migration
2. Slow temperate migration rate predicted by the STM
3. Tension between potential and realized distribution (at equilibrium with climate)

Aknowledgements

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Funded by

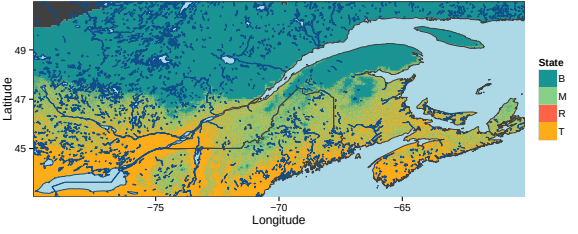
NSERC CRSNG

In collaboration with

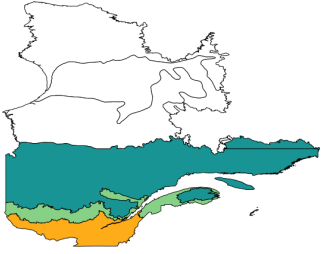
Ontario
Ressources naturelles Québec
Natural Resources Canada / Ressources naturelles Canada
Domtar
OURANOS

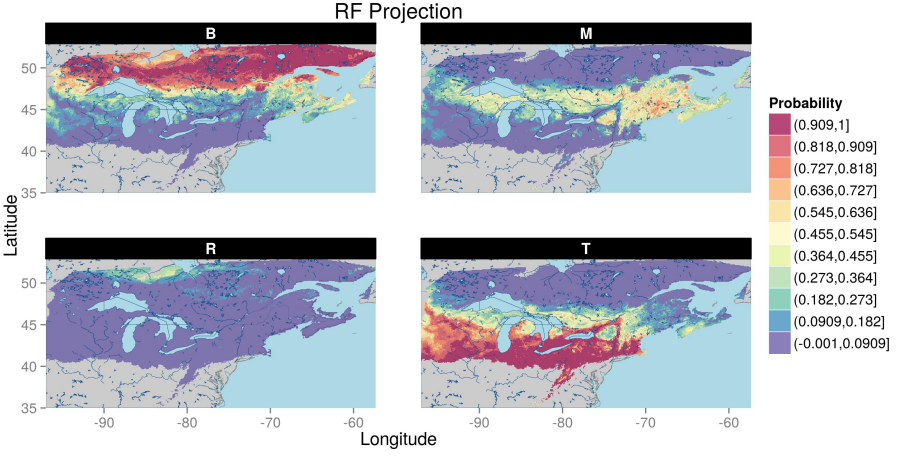
$$P(D_{t1}|M_{t0}, Climate) = f(\overbrace{Climate, \underbrace{\hat{D}, \hat{M}}_{\text{Step 1. RandomForest}}}^{\text{Step 2. Simulated anenaling}}) \quad (1)$$

Landscape predicted by the STM



Bioclimatic domains in Quebec




RF Projection
B
M
R
T
Latitude
50
45
40
35
-90
-80
-70
-60
Longitude
Probability
(0.909,1]
(0.818,0.909]
(0.727,0.818]
(0.636,0.727]
(0.545,0.636]
(0.455,0.545]
(0.364,0.455]
(0.273,0.364]
(0.182,0.273]
(0.0909,0.182]
(-0.001,0.0909]