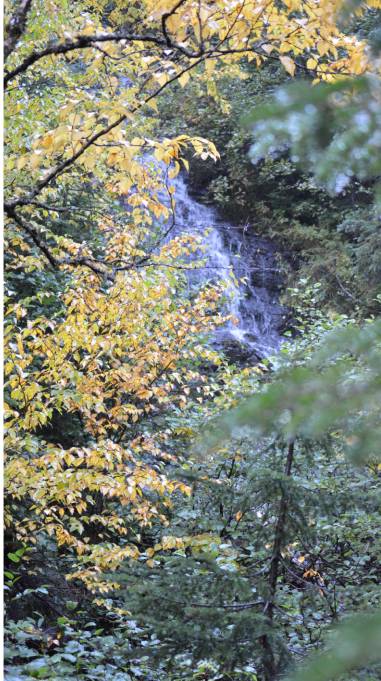
Université du Québec à Rimouski October 17, 2014

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

Steve Vissault, Matthew Talluto,
Isabelle Boulangeat and Dominique Gravel

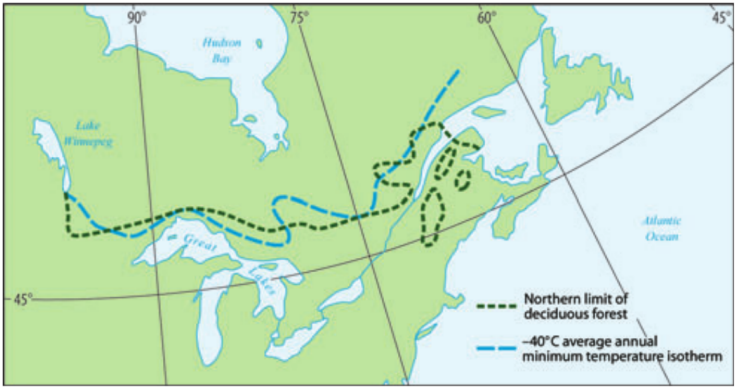
QUICCY FOR
Quantifying and mapping the impact of climate change on forest productivity in Eastern Canada



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

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

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Sugar maple

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Sugar maple

Yellow birch

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

Sugar maple

Red oak

Yellow birch

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

Sugar maple

Red oak

Yellow birch

American ash

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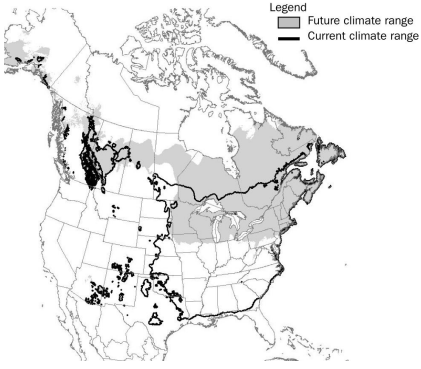
2. Several temperate forest species are predicted to **shift northward** under climate change



Future climate enveloppe of Sugar maple (2071-2100)

McKenney *et al*, 2007

Forest have:

1. Limited dispersions
2. Slow population dynamics
3. Successional stages (dynamic communities)

Travis *et al*, 2013

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To predict species or communities range shift we need to include:

- Spatial interactions (e.g. competition)
- Population demography

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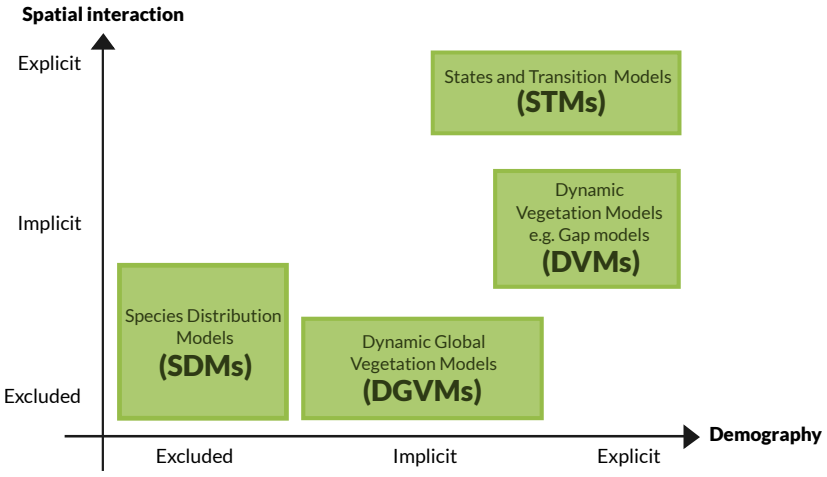
These components will be effected by future climate

Travis *et al*, 2013



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

Study ojective

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

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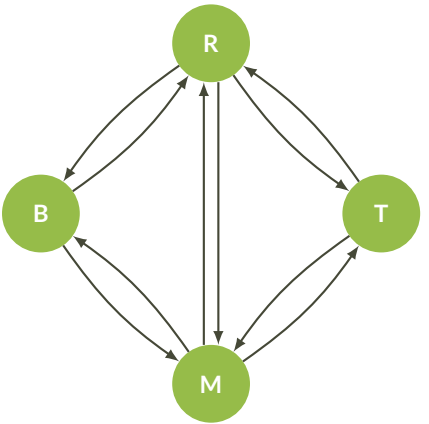
Why ?

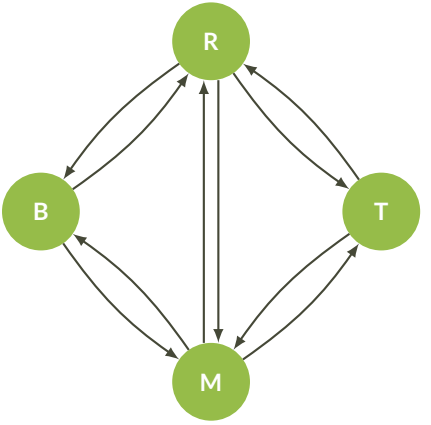
- Predict the future distribution of temperate species community in Quebec
- Improve and adapt our forests management practices under climate change



Model Description

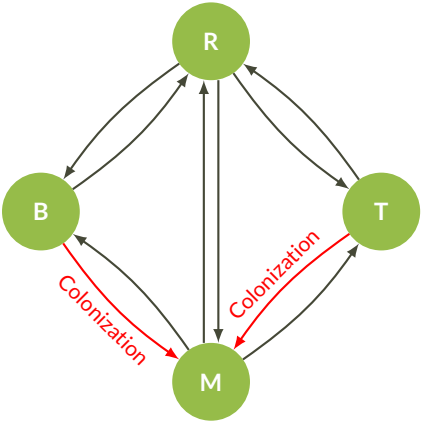
- Lanscape scale
- **4 States:**
  - **B** Boreal forest
  - **M** Mixed forest
  - **T** Temperate forest
- **R** corresponds to a post-disturbance patch
- Spatially explicit and stochastic model

New approach States and Transitions Model



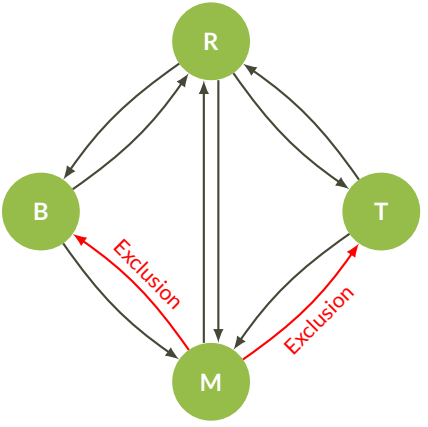
States	Classification
T	$Ba_t \geq 75\%$
M	$Ba_b \geq 25\%$ and $Ba_t \geq 25\%$
B	$Ba_b \geq 75\%$
R	$Ba \leq 10 m_2 / ha$

*Ba means basal area (m_2/ha)



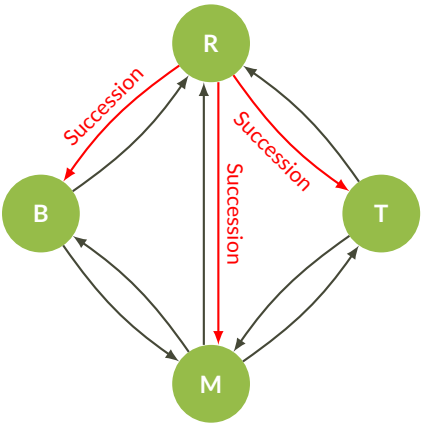
Ecological processes:

- Colonization



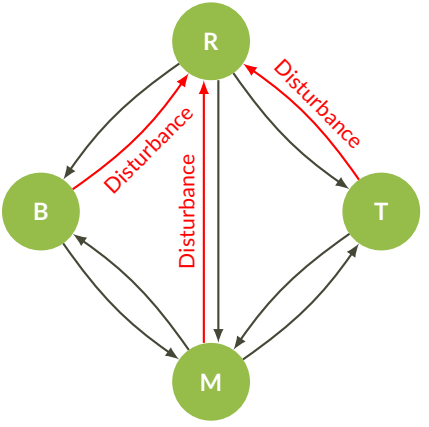
Ecological processes:

- Colonization
- Competitive exclusion



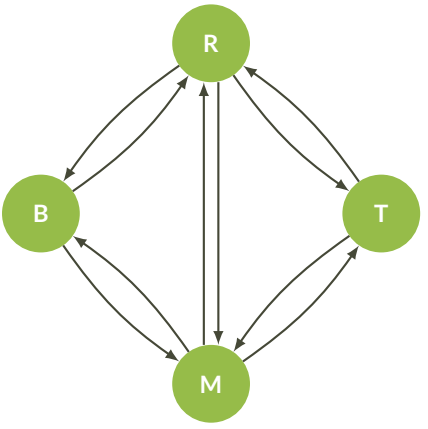
Ecological processes:

- Colonization
- Competitive exclusion
- Succession



Ecological processes:

- Colonization
- Competitive exclusion
- Succession
- Disturbance

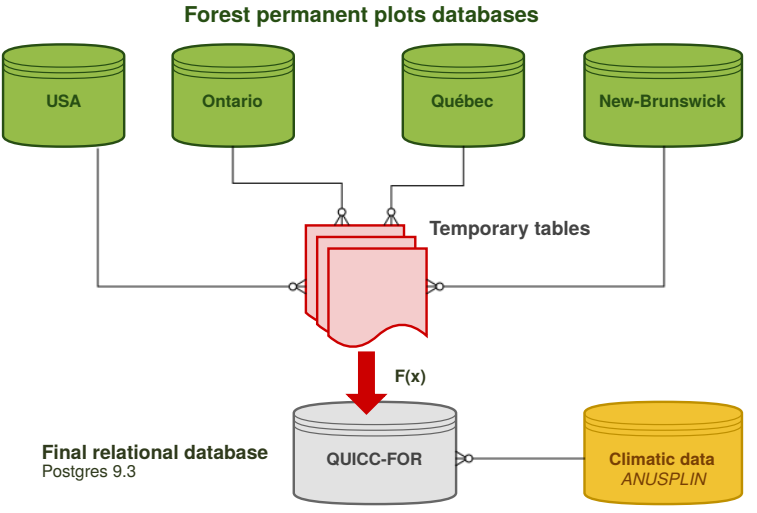


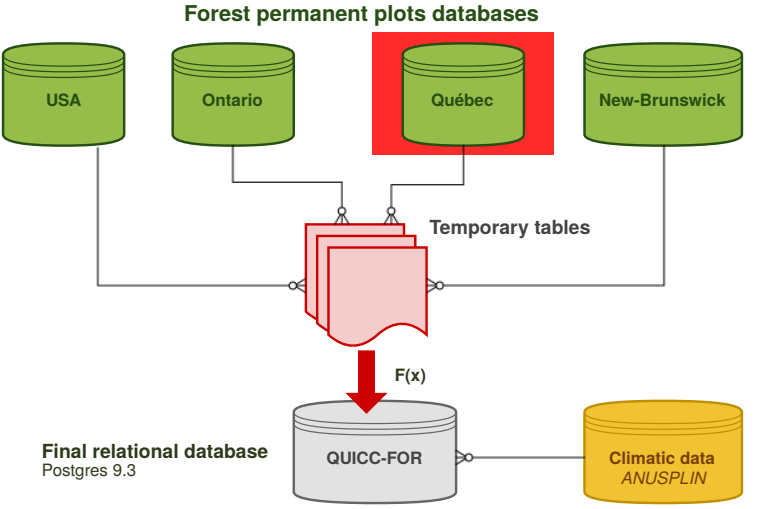
Ecological processes:

- Colonization
- Competitive exclusion
- Succession
- Disturbance

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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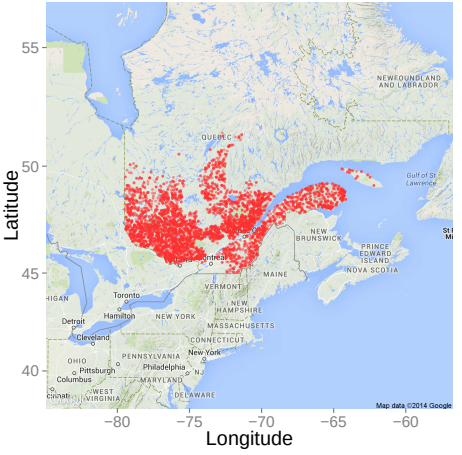
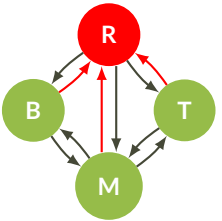
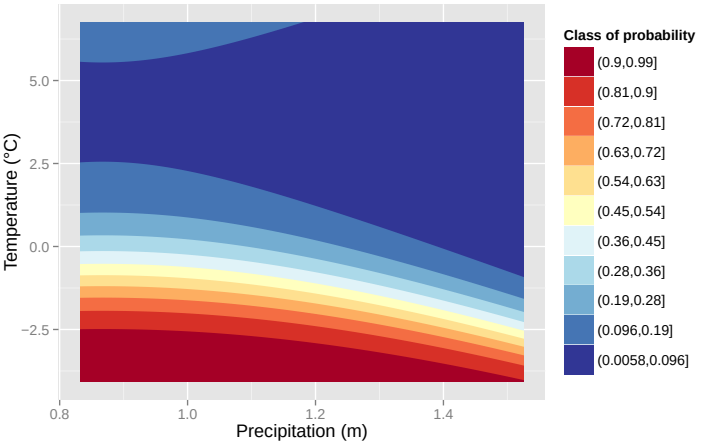
CALIBRATION DATA USED

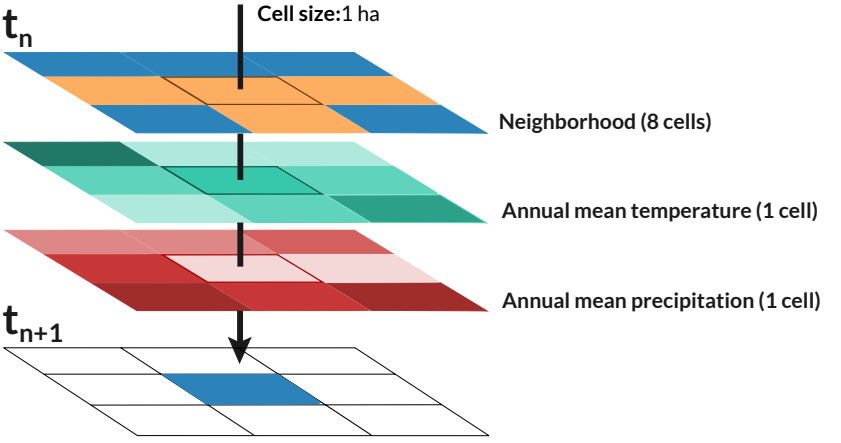


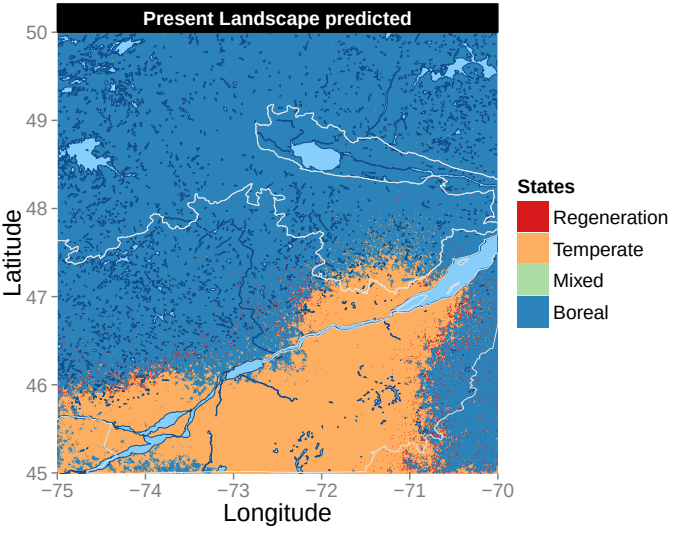
1. **Classify state of each plot**
   - Plot remeasured (10 years)
   - Transition observed between remeasurements
   - Past-climate of the plot over 15 years
2. **Compute state transition probabilities** based on the actual climate and neighbors plots states.

CALIBRATION TRANSITION PROBABILITIES OVER CLIMATIC GRADIENTS

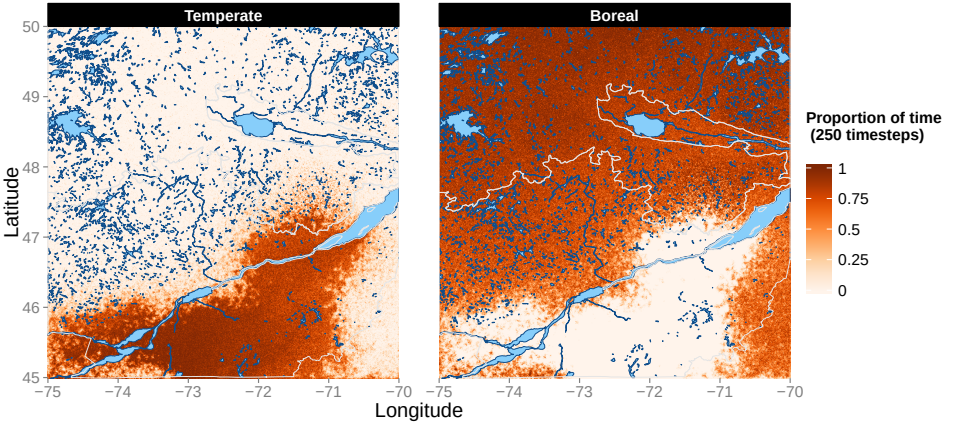


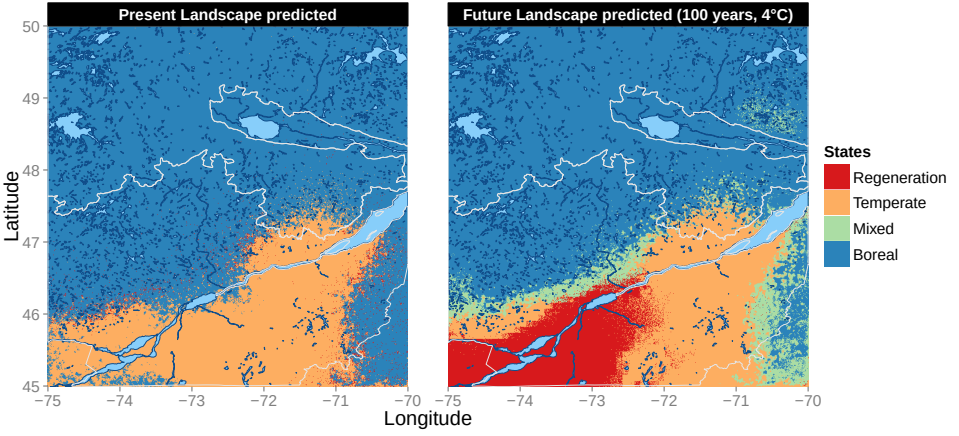



t_n
Cell size: 1 ha
Neighborhood (8 cells)
Annual mean temperature (1 cell)
Annual mean precipitation (1 cell)
t_{n+1}


Present Landscape predicted
Latitude
Longitude
50
49
48
47
46
45
−75
−74
−73
−72
−71
−70
States
Regeneration
Temperate
Mixed
Boreal

RESULTS ACTUAL PREDICTED LANDSCAPE




Present Landscape predicted
Future Landscape predicted (100 years, 4°C)
Latitude
Longitude
50
49
48
47
46
45
−75
−74
−73
−72
−71
−70
States
Regeneration
Temperate
Mixed
Boreal

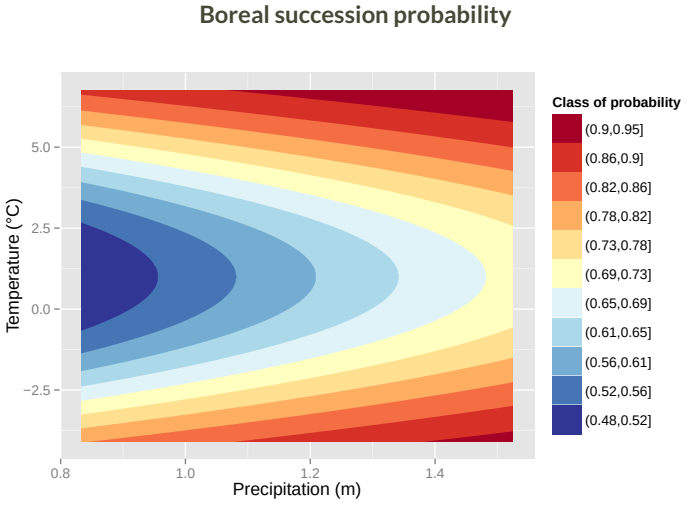
Incomings

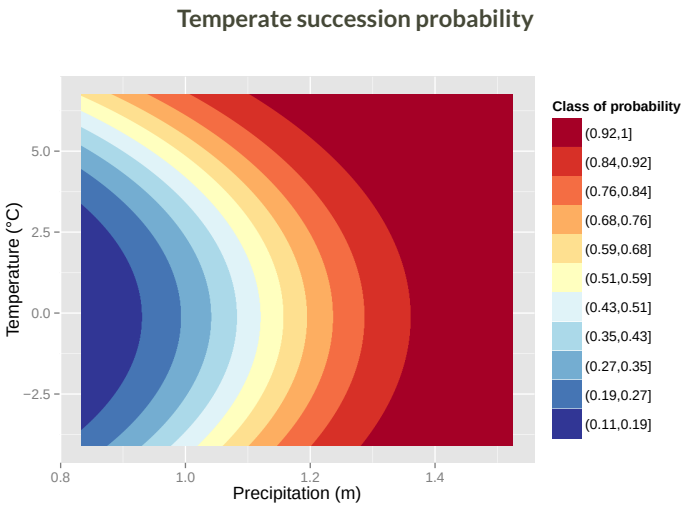
Next steps:

1. Add all data from the QUICC-FOR database
2. Improve the calibration
3. Process validation
4. Perform simulations using Regional Climate Models (RCM)

Thanks for your attention.
Any Questions ?

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


Boreal succession probability
Class of probability
(0.9,0.95]
(0.86,0.9]
(0.82,0.86]
(0.78,0.82]
(0.73,0.78]
(0.69,0.73]
(0.65,0.69]
(0.61,0.65]
(0.56,0.61]
(0.52,0.56]
(0.48,0.52]
Temperature (°C)
5.0
2.5
0.0
−2.5
0.8
1.0
1.2
1.4
Precipitation (m)


Temperate succession probability
Class of probability
(0.92,1]
(0.84,0.92]
(0.76,0.84]
(0.68,0.76]
(0.59,0.68]
(0.51,0.59]
(0.43,0.51]
(0.35,0.43]
(0.27,0.35]
(0.19,0.27]
(0.11,0.19]
Temperature (°C)
5.0
2.5
0.0
−2.5
0.8
1.0
1.2
1.4
Precipitation (m)