

## DIFFICULT MIGRATION OF TEMPERATE TREE SPECIES IN BOREAL FOREST UNDER CLIMATE CHANGE?

Steve Vissault, Matthew Talluto,  
Isabelle Boulangéat and Dominique Gravel



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



---

## CONTEXT THE BOREAL-TEMPERATE ECOTONE

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



---

## CONTEXT THE BOREAL-TEMPERATE ECOTONE

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



---

## CONTEXT PREDICTED FUTURE SPECIES DISTRIBUTION

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



Sugar maple



Red oak



Yellow birch

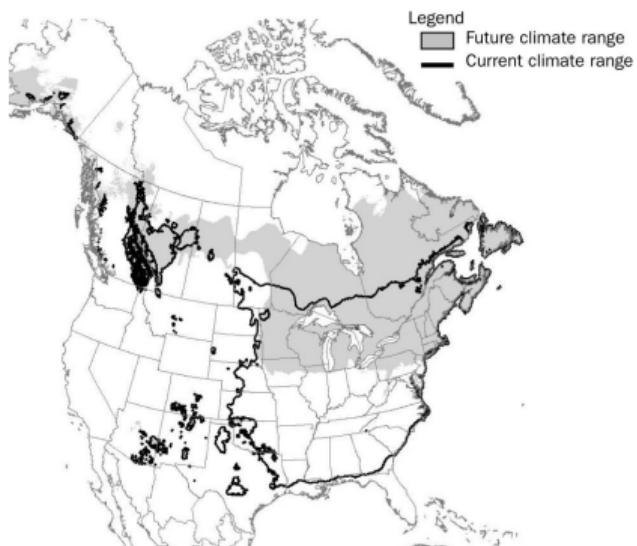


American ash

---

## CONTEXT PREDICTED FUTURE SPECIES DISTRIBUTION

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



Future climate enveloppe of Sugar maple (2071-2100)

---

## CONTEXT LIMITS AND DIFFICULTIES IN THIS STUDY CONTEXT

**Forest have:**

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

---

## CONTEXT LIMITS AND DIFFICULTIES IN THIS STUDY CONTEXT

Forest have:

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

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

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

---

## CONTEXT LIMITS AND DIFFICULTIES IN THIS STUDY CONTEXT

Forest have:

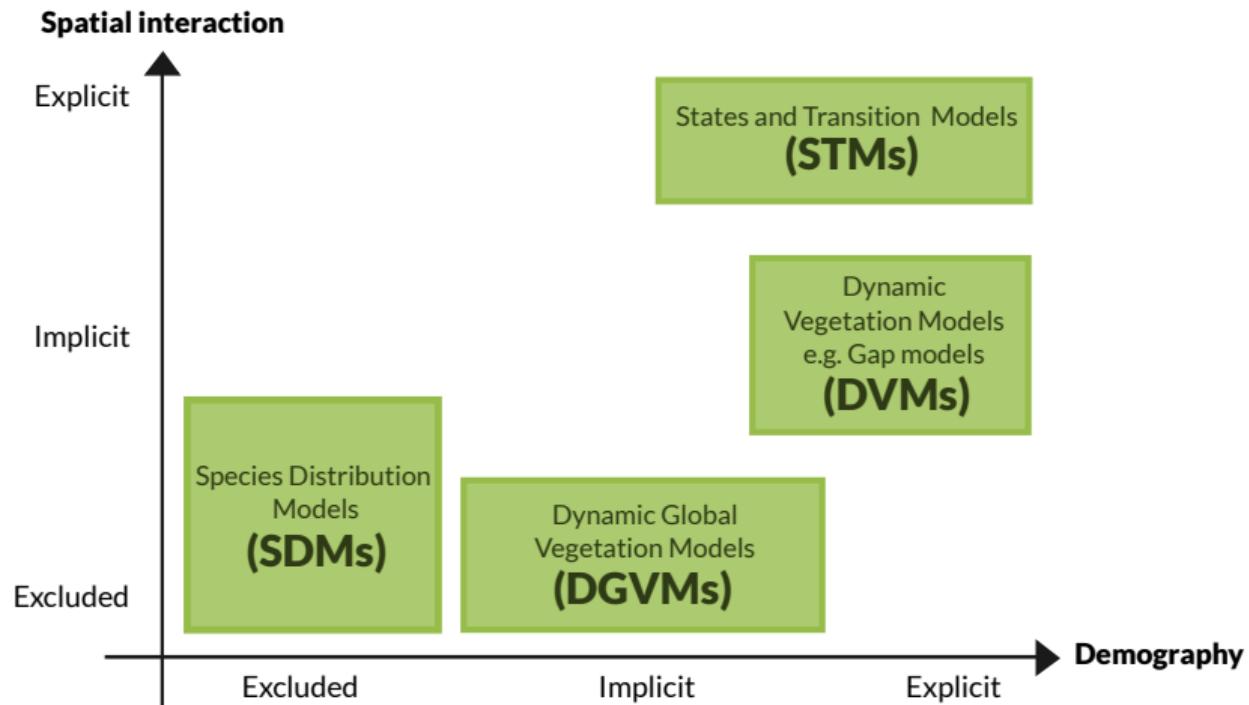
1. Limited dispersions
2. Slow population dynamics
3. Successional stages (dynamic communities)

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

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

These components will be effected by future climate

## CONTEXT MODELLING COMPROMISE



---

## STUDY OBJECTIVE

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

---

## STUDY OBJECTIVE

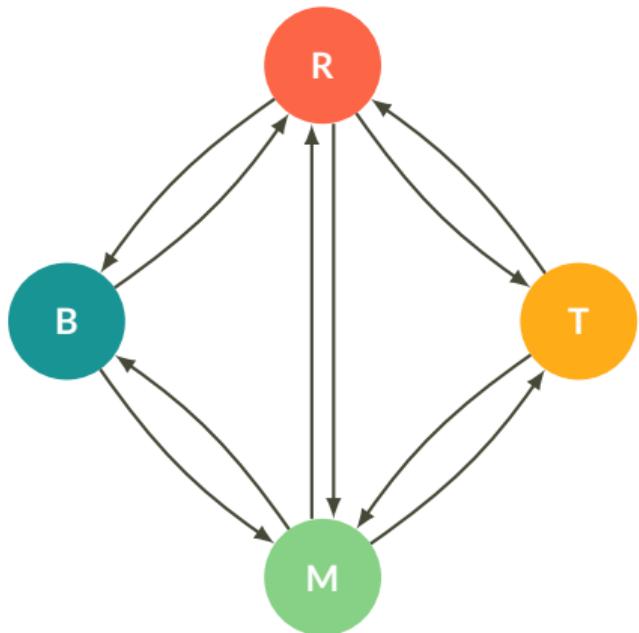
**Main objective:** Assess range shift and migration rates of the temperate forest community toward boreal forest under climate change.

### Why ?

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

---

## NEW APPROACH STATES AND TRANSITIONS MODEL

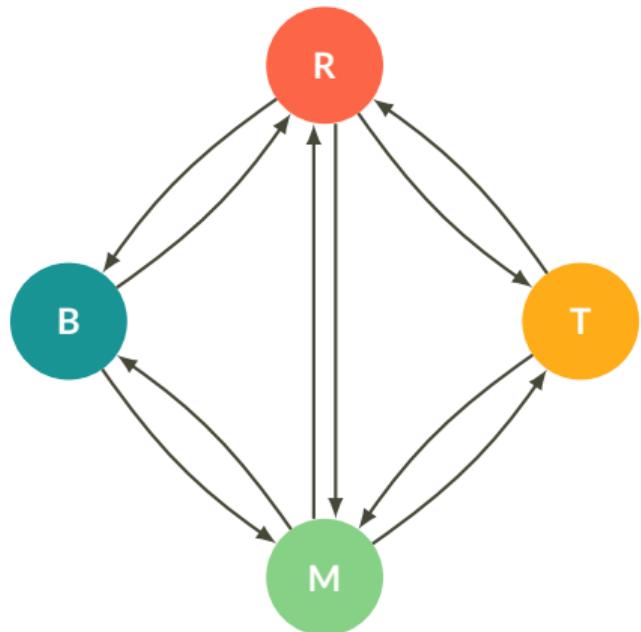


### Model Description

- Landscape 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	$Ba_b \geq 25\% \text{ and } Ba_t \geq 25\%$
B	$Ba_b \geq 75\%$
R	$Ba \leq 10m_2/\text{ha}$

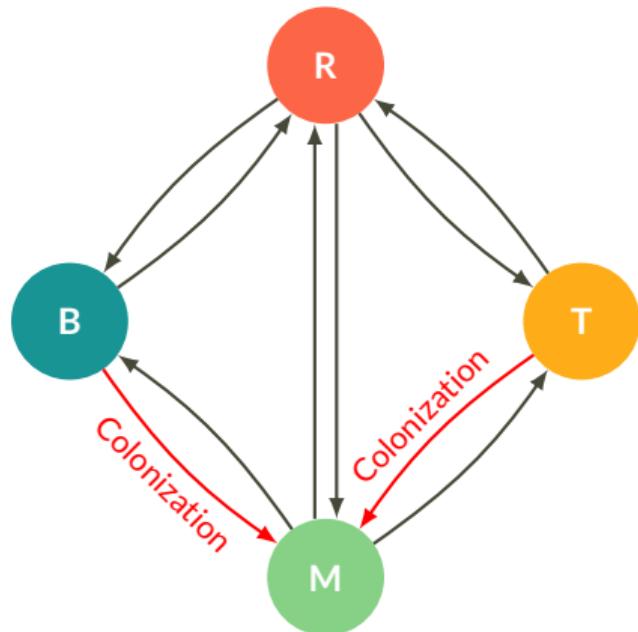
\* $Ba$  means basal area ( $m_2/\text{ha}$ )

---

## NEW APPROACH STATES AND TRANSITIONS MODEL

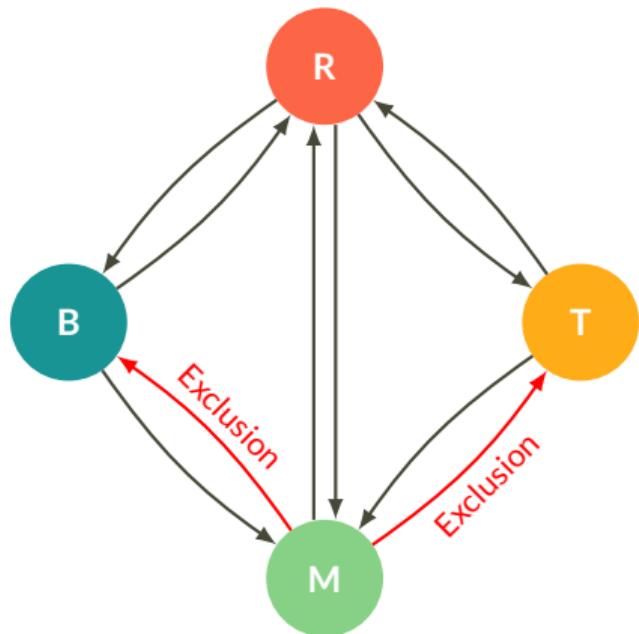
Ecological processes:

- Colonization



---

## NEW APPROACH STATES AND TRANSITIONS MODEL

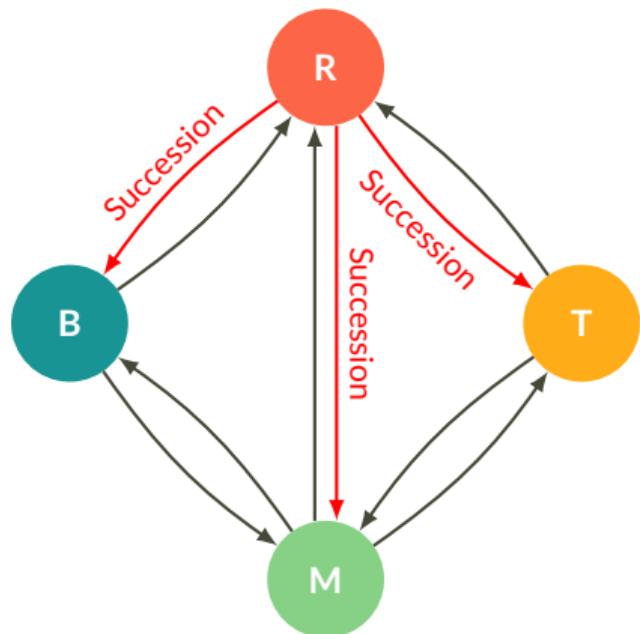


**Ecological processes:**

- Colonization
- Competitive exclusion

---

## NEW APPROACH STATES AND TRANSITIONS MODEL

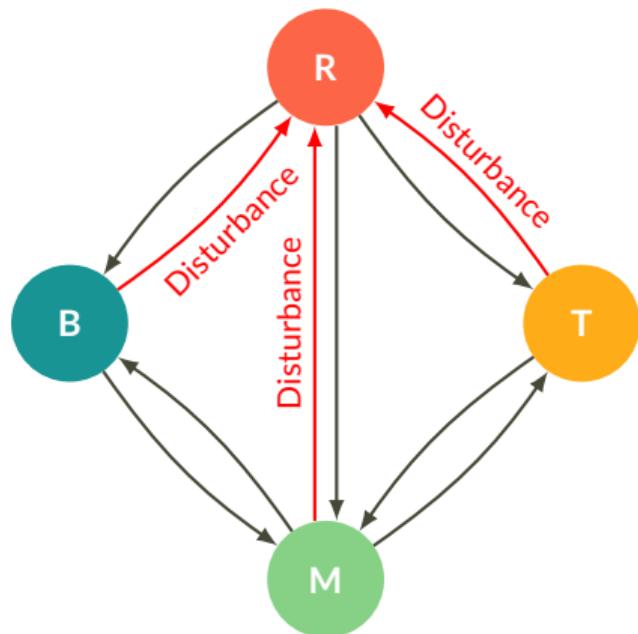


### Ecological processes:

- Colonization
- Competitive exclusion
- Succession

---

## NEW APPROACH STATES AND TRANSITIONS MODEL

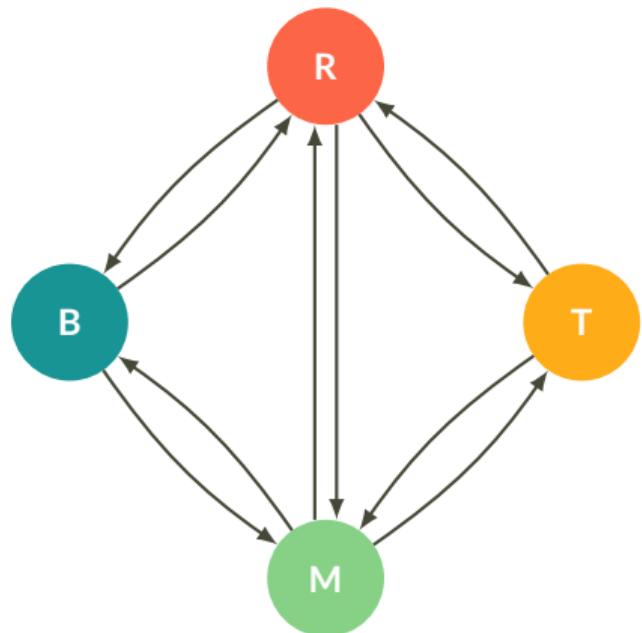


### Ecological processes:

- Colonization
- Competitive exclusion
- Succession
- Disturbance

---

## NEW APPROACH STATES AND TRANSITIONS MODEL



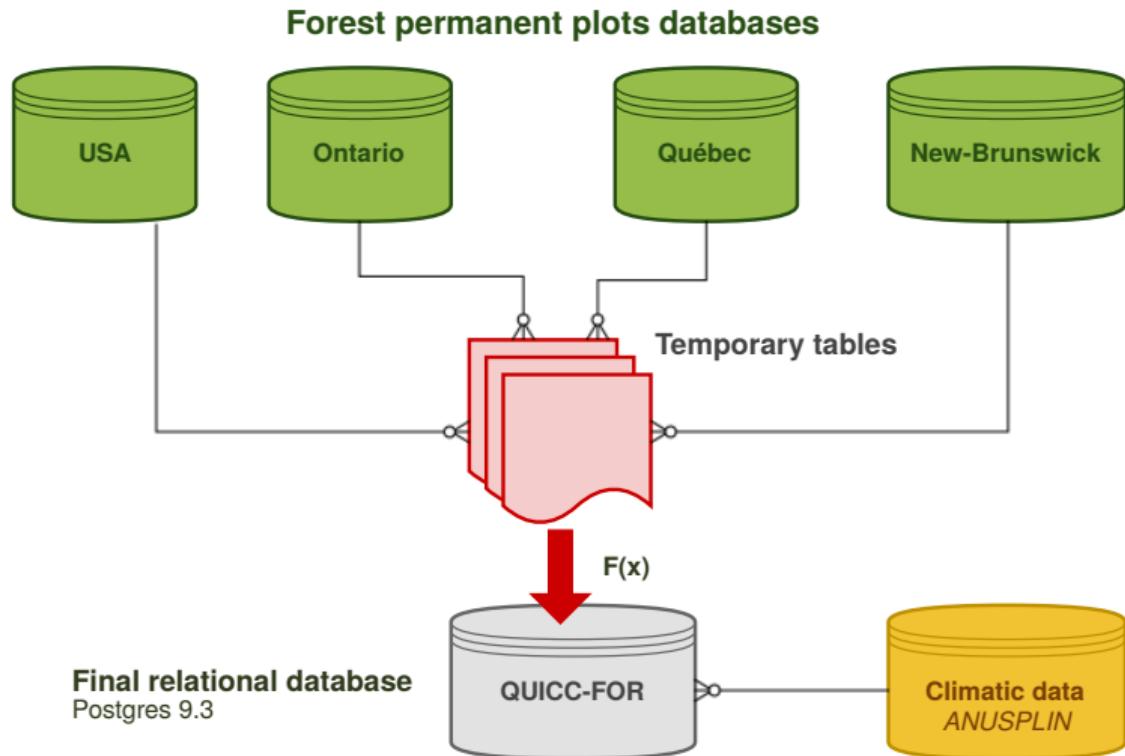
### Ecological processes:

- Colonization
- Competitive exclusion
- Succession
- Disturbance

### Each probability depends on:

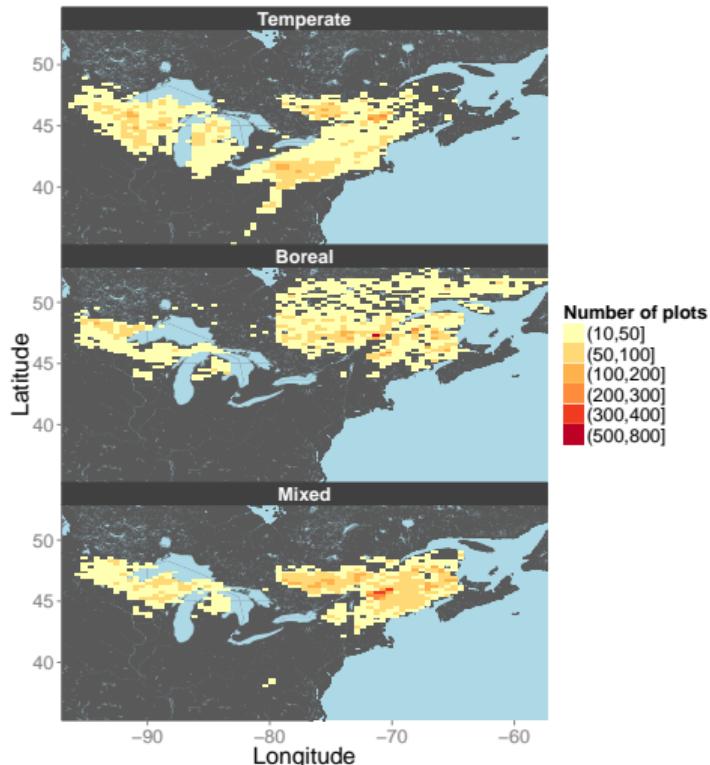
- Proportion of states available in the neighborhood
- Local climatic conditions (Precipitation, Temperature)

## DATA THE QUICC-FOR DATABASE



---

## CALIBRATION DATA USED

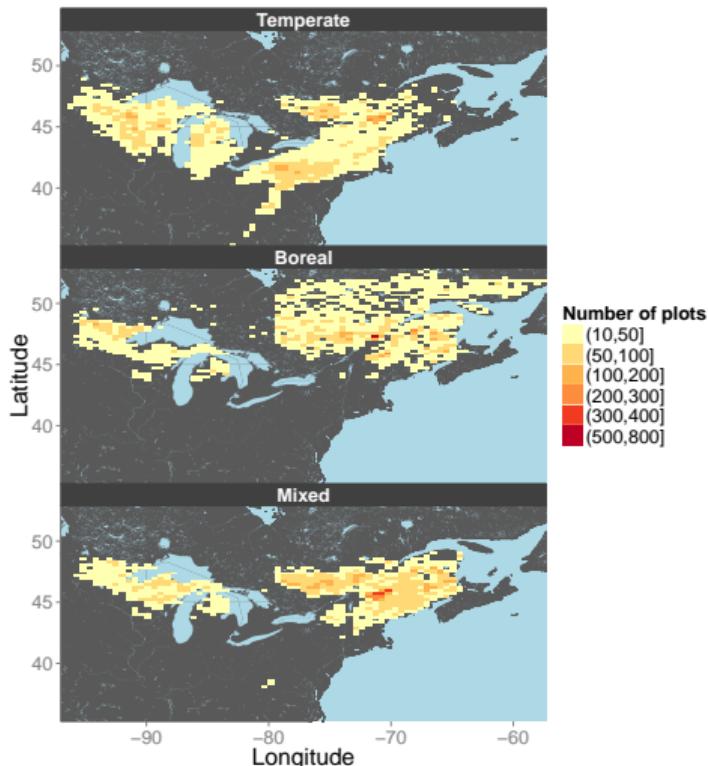


### 1. Classify state of each plot

- Plot remeasured (10 years)
- Transition observed between remeasurements
- Past-climate of the plot over 15 years

---

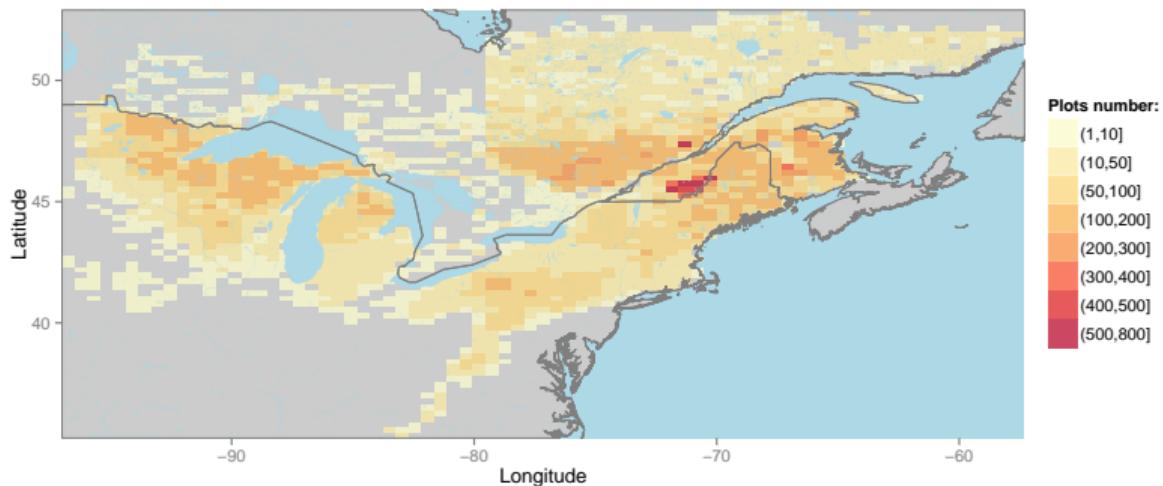
## CALIBRATION    DATA USED



- 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**

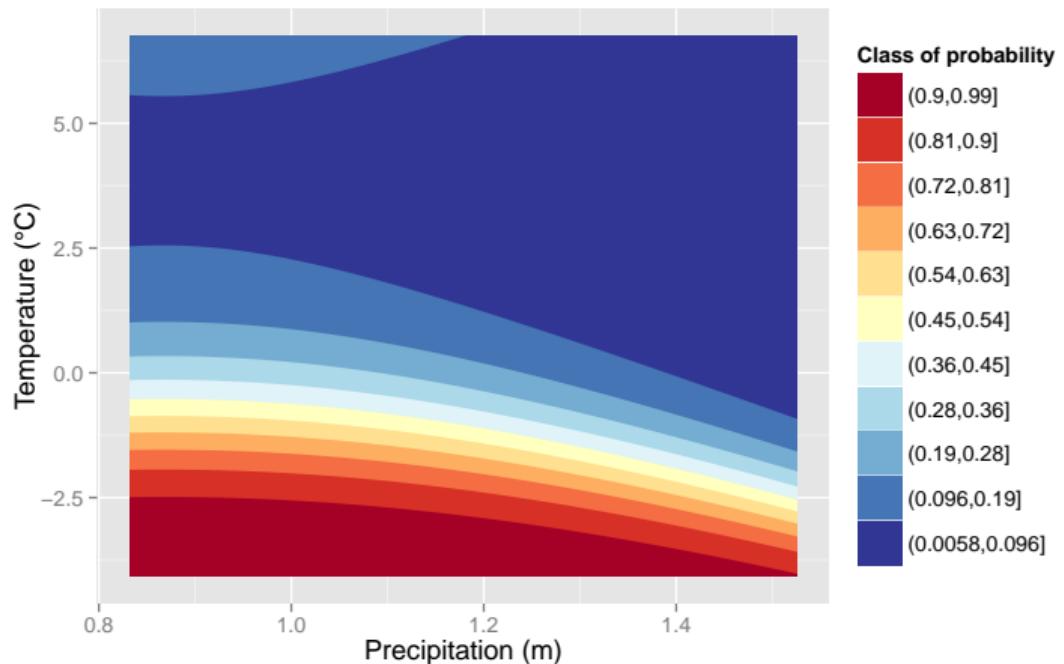
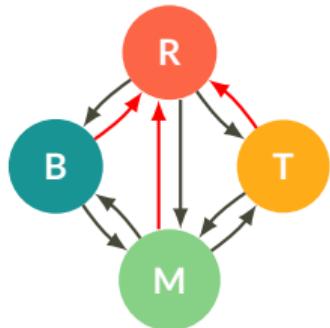
based on the actual climate and neighbors plot states.

2. Compute state transition probabilities based on the actual climate and neighbors plot states.



---

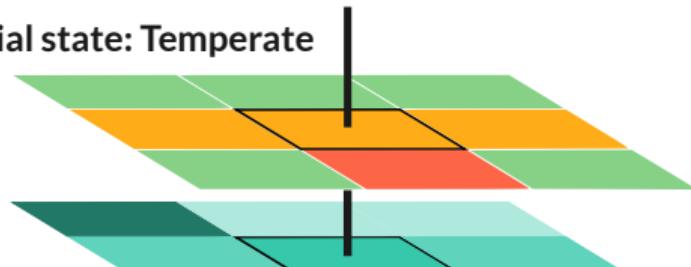
## CALIBRATION    TRANSITION PROBABILITIES OVER CLIMATIC GRADIENTS



---

## RESULTS SIMULATIONS

Initial state: Temperate



Cell area: 1 ha

Neighborhood (8 cells)

Annual mean temperature (1 cell)

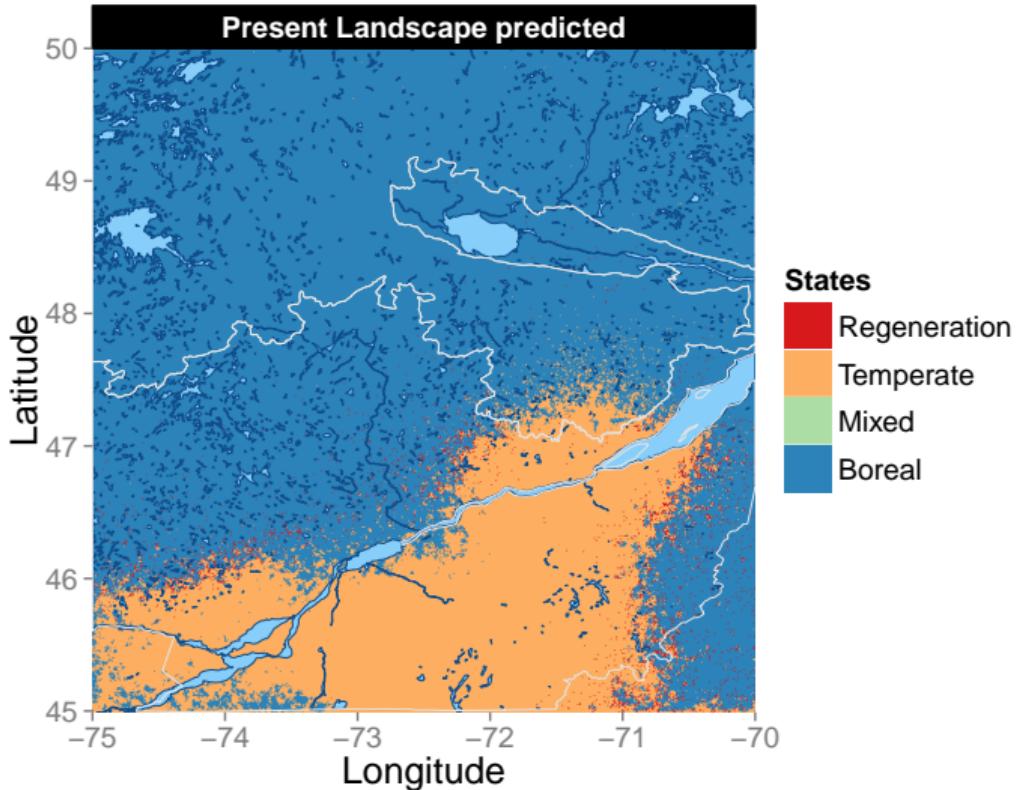
State at the next step ?



Annual mean precipitation (1 cell)

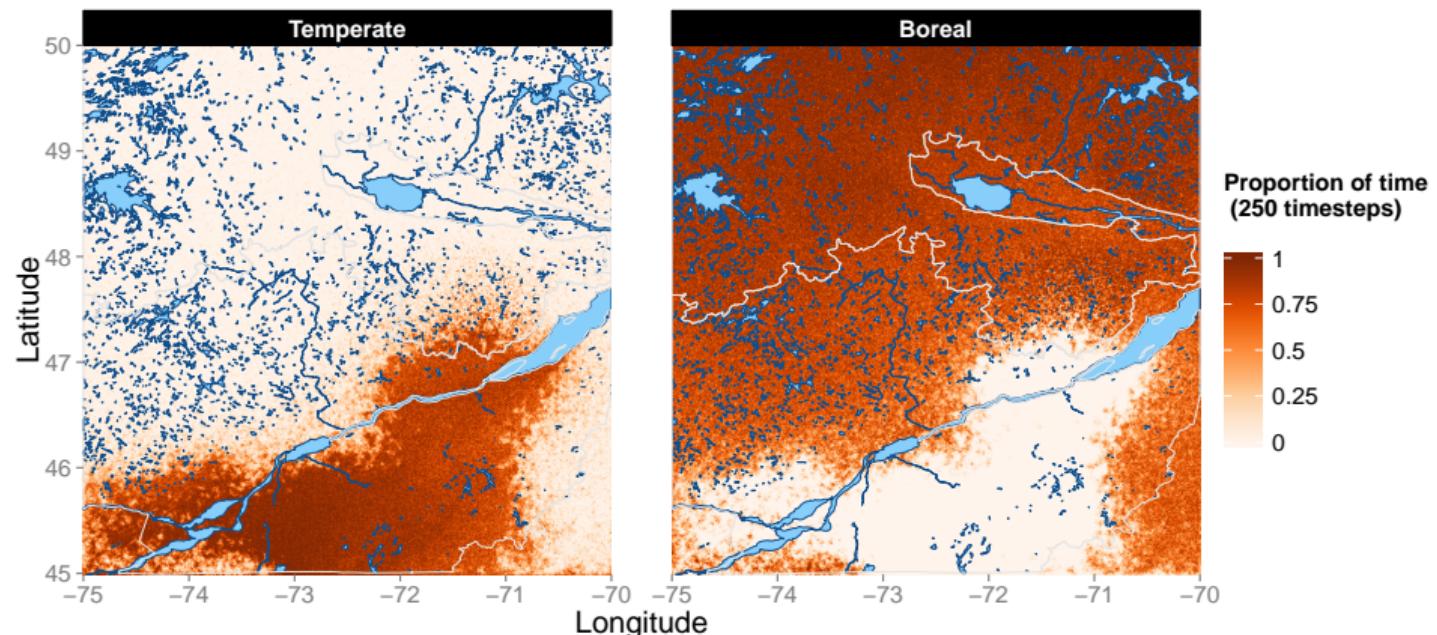
---

## RESULTS ACTUAL PREDICTED LANDSCAPE



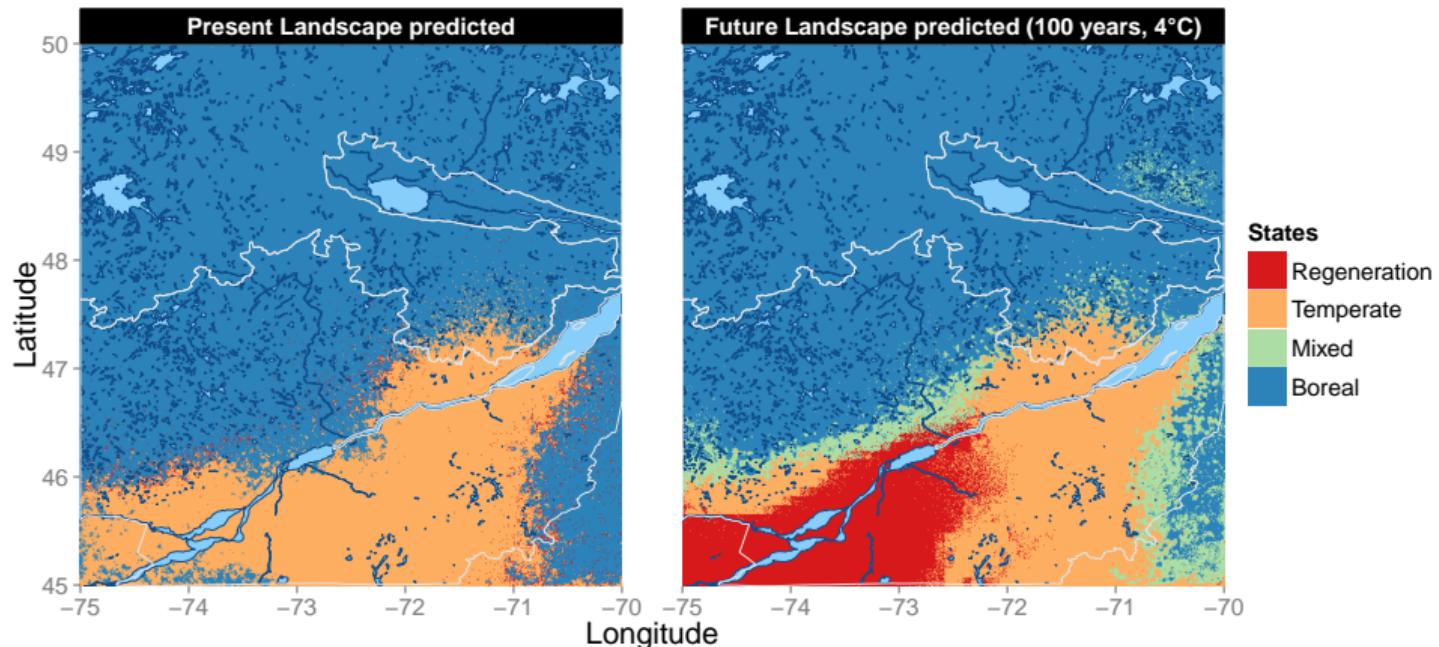
---

## RESULTS ACTUAL PREDICTED LANDSCAPE



---

## RESULTS FUTUR PREDICTED LANDSCAPE



---

## 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)

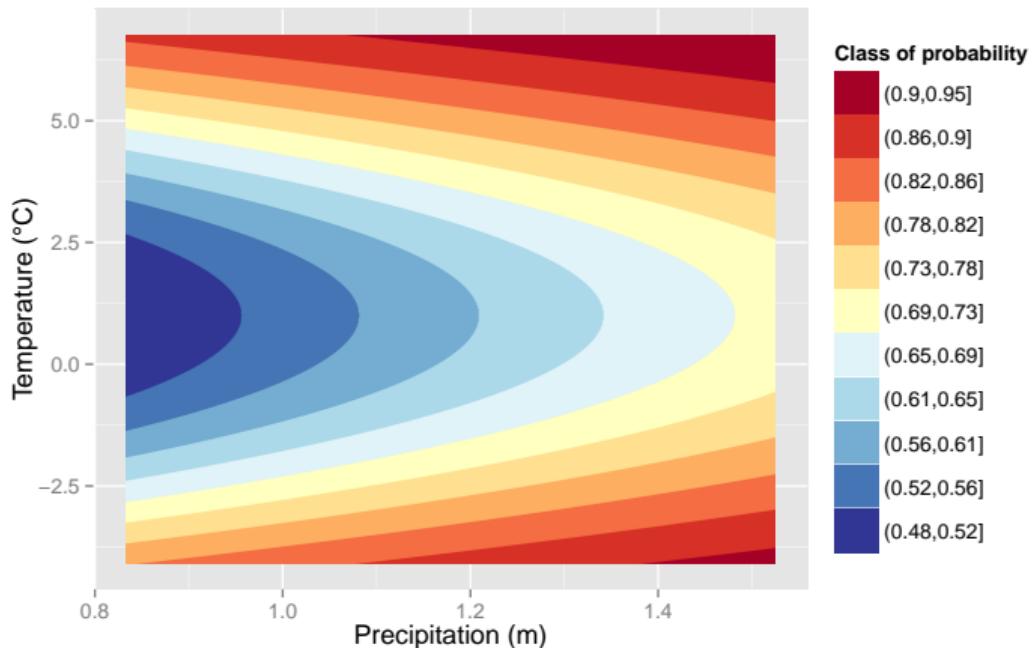
---

## QUESTIONS

**Thanks for your attention.**  
Any Questions ?

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

### Boreal succession probability



### Temperate succession probability

