

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

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



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## CONTEXT THE BOREAL-TEMPERATE ECOTONE

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



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## CONTEXT THE BOREAL-TEMPERATE ECOTONE

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



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## CONTEXT PREDICTED FUTURE SPECIES DISTRIBUTION

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



Sugar maple



Red oak



Yellow birch

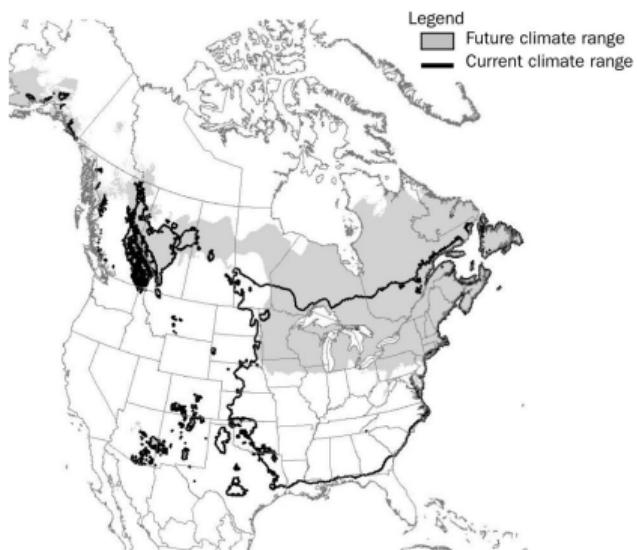


American ash

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## 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)

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## CONTEXT LIMITS AND DIFFICULTIES IN THIS STUDY CONTEXT

Forest have:

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

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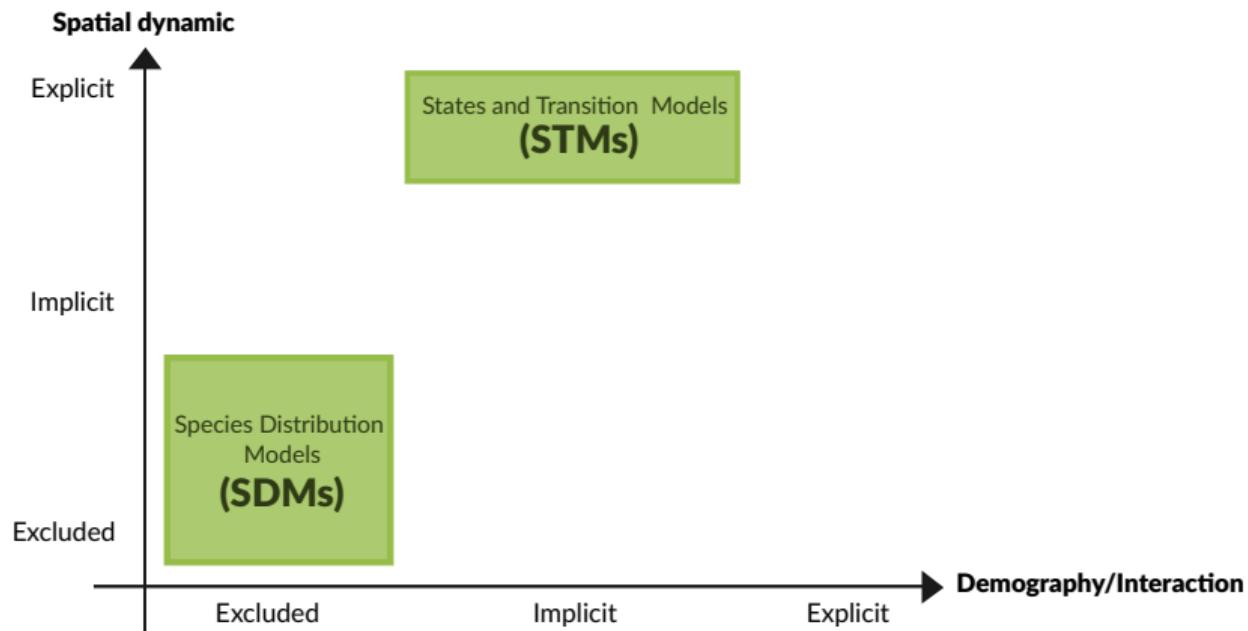
## CONTEXT LIMITS AND DIFFICULTIES IN THIS STUDY CONTEXT

Forest have:

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

**These components will be affected by future climate**

## CONTEXT MODELLING COMPROMISE



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## 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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## STUDY OBJECTIVE

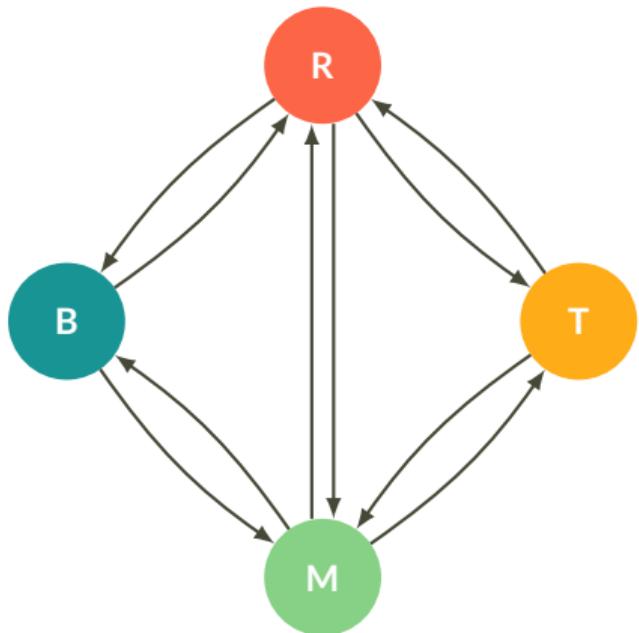
**Main objective:** Assess range shift and migration rates of the temperate forest community toward boreal forest under climate change.

### Why?

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

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## NEW APPROACH STATES AND TRANSITIONS MODEL



### Model Description

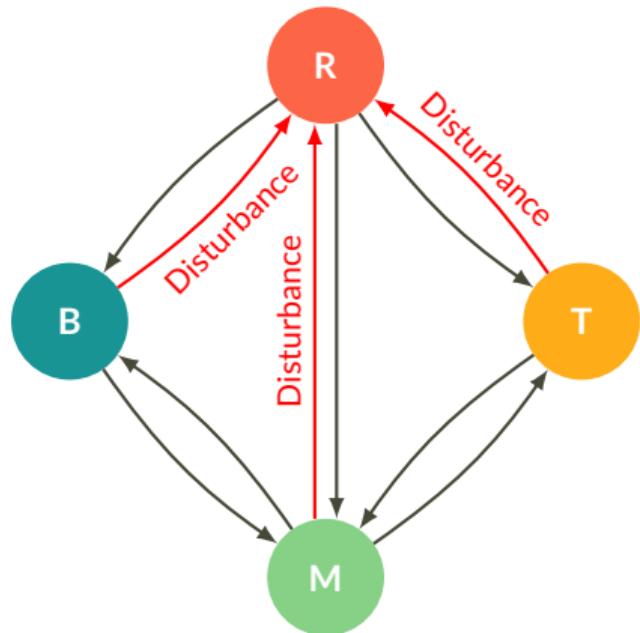
- Landscape scale
- 4 States:
  - **T**, Temperate
  - **B**, Boreal
  - **M**, Mixed
  - **R**, corresponds to a post-disturbance
- Spatially explicit and stochastic model

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## NEW APPROACH STATES AND TRANSITIONS MODEL

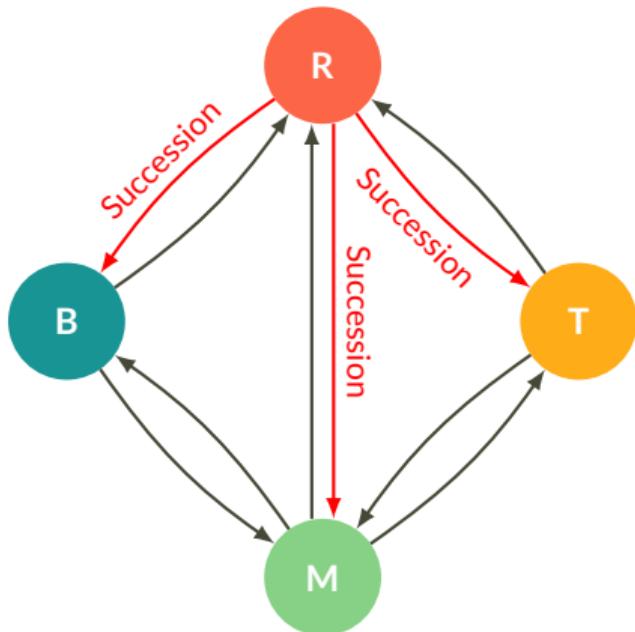
Ecological processes:

- Disturbance



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## NEW APPROACH STATES AND TRANSITIONS MODEL

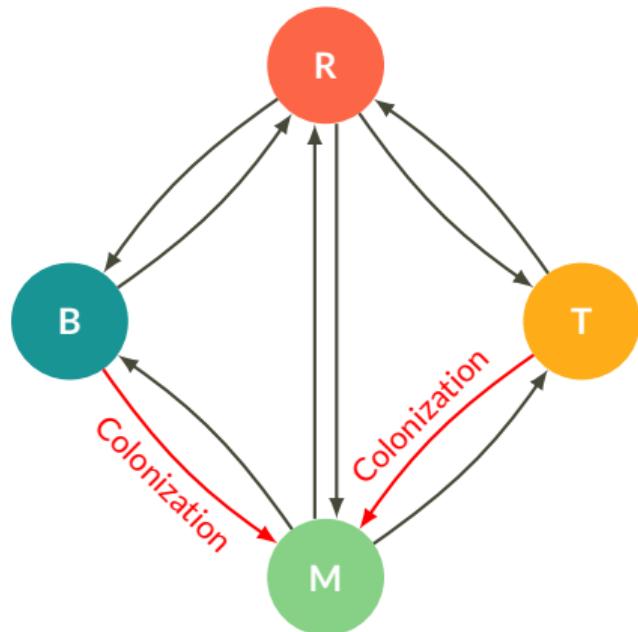


Ecological processes:

- Disturbance
- Succession

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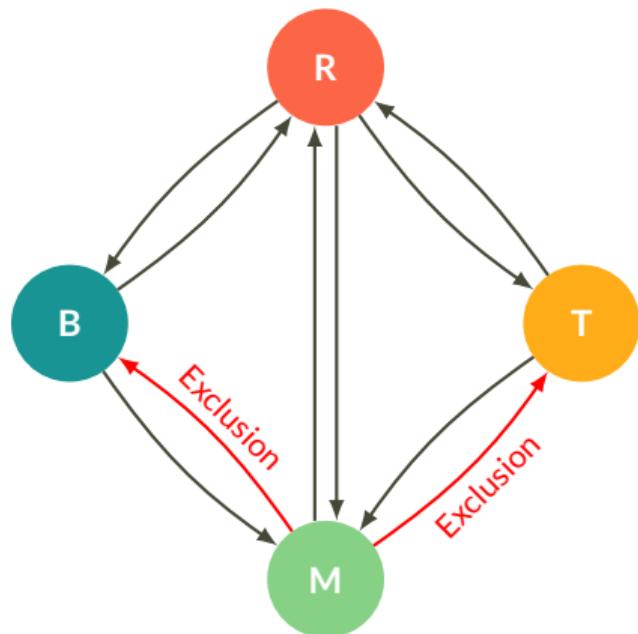


### Ecological processes:

- Disturbance
- Succession
- Colonization

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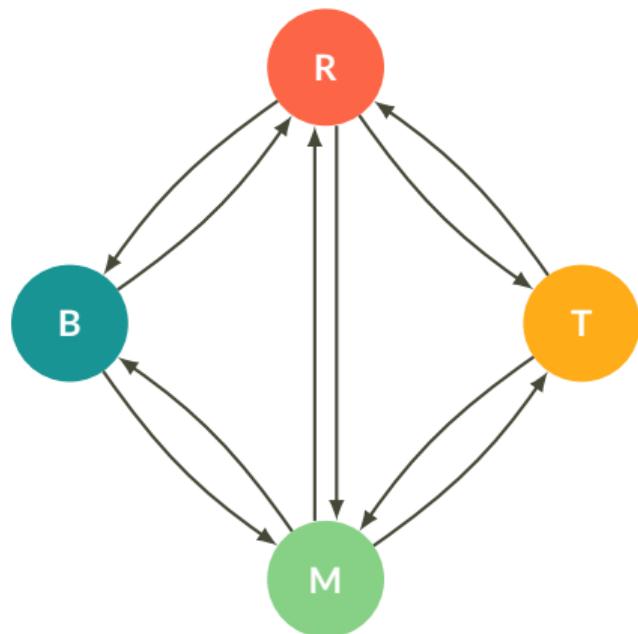


### Ecological processes:

- Disturbance
- Succession
- Colonization
- Competitive exclusion

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## NEW APPROACH STATES AND TRANSITIONS MODEL



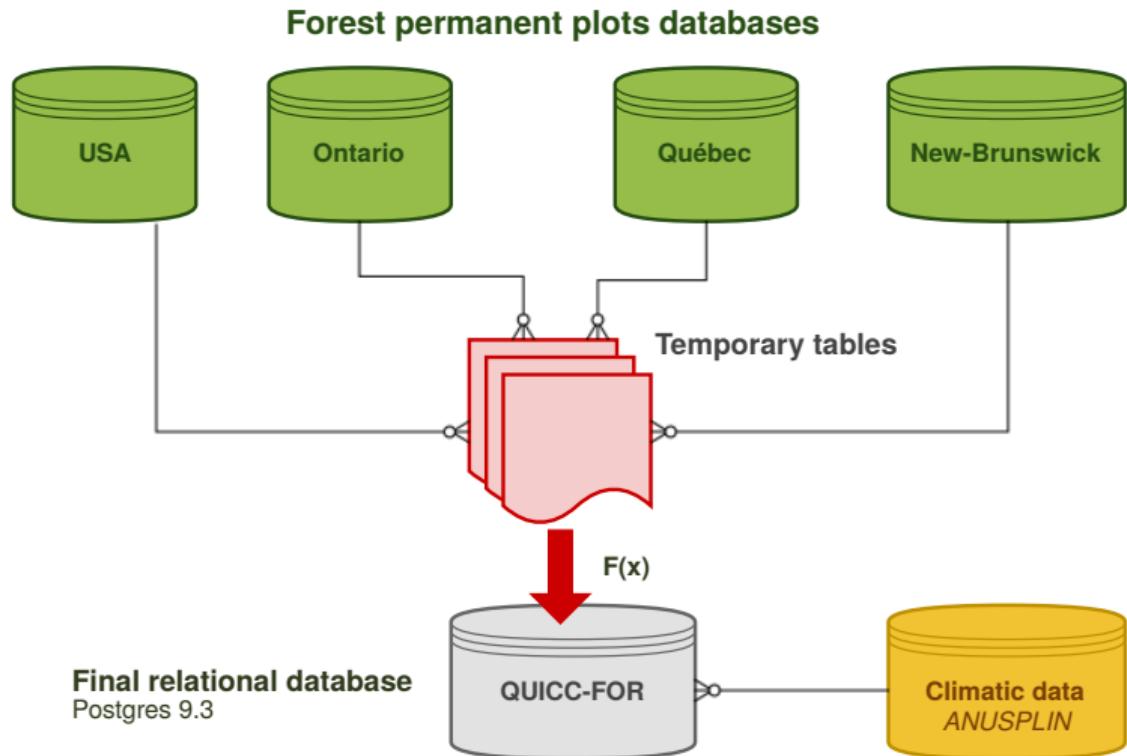
### Ecological processes:

- Disturbance
- Succession
- Colonization
- Competitive exclusion

### Each probability depends on:

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

## DATA THE QUICC-FOR DATABASE



## 1. Classify state of each plot

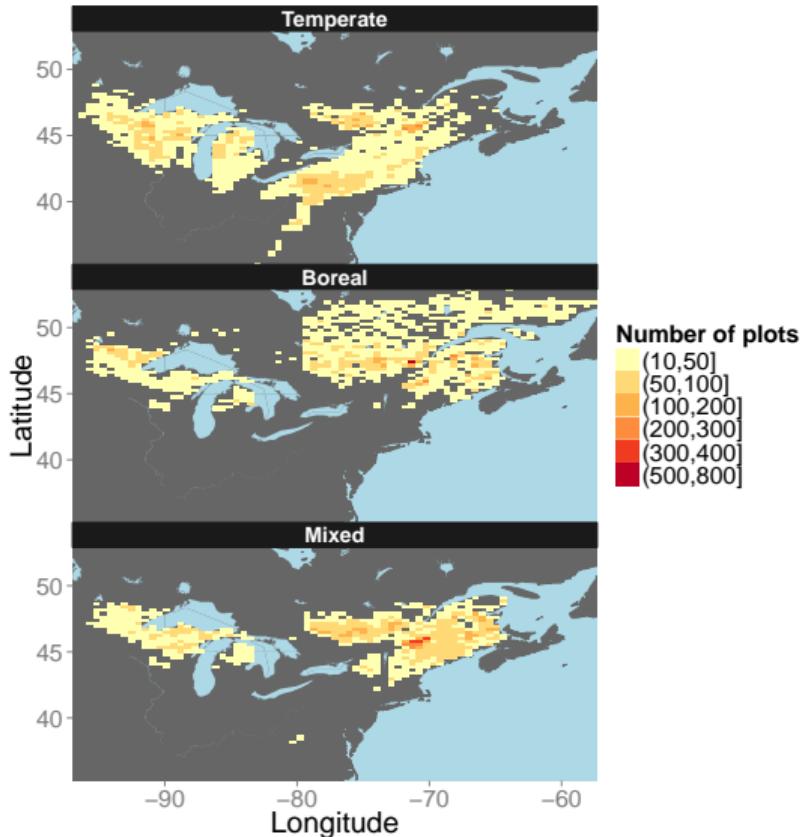
- Plot remeasured
- Transition observed between  
remeasurements

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## CALIBRATION    DATA USED

### 1. Classify state of each plot

- Plot remeasured
- Transition observed between remeasurements



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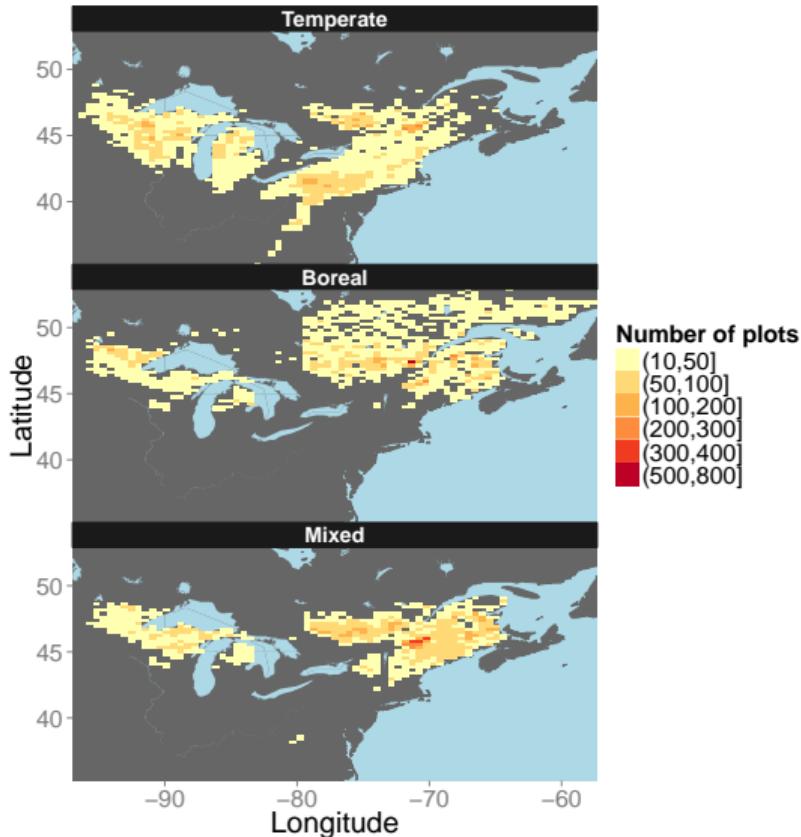
## CALIBRATION    DATA USED

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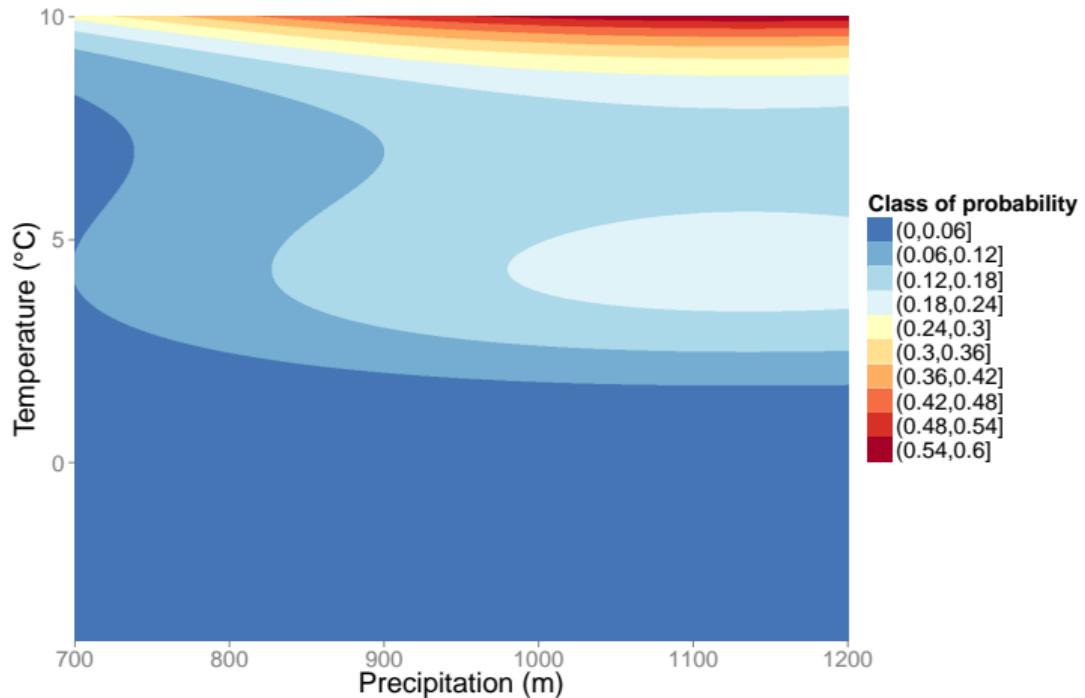
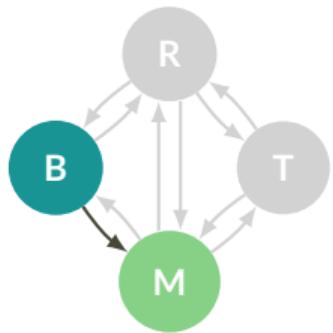
### 2. Compute state transition

probabilities based on the actual climate and neighbors plot states.



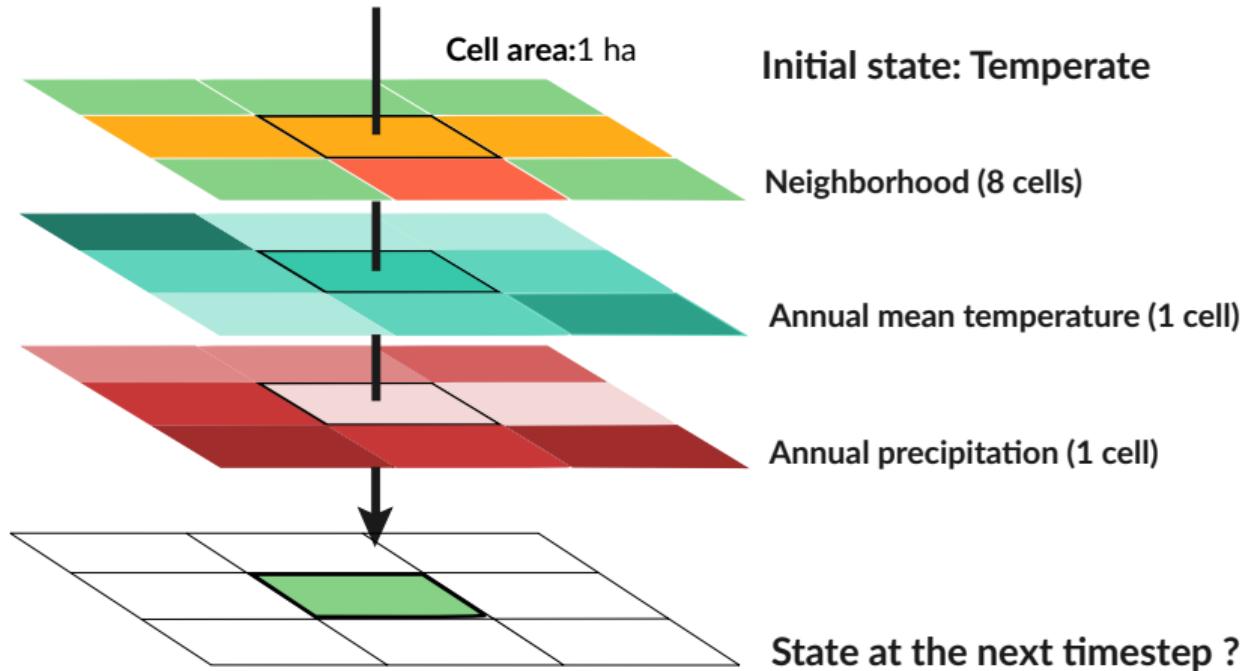
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## CALIBRATION    TRANSITION PROBABILITIES OVER CLIMATIC GRADIENTS



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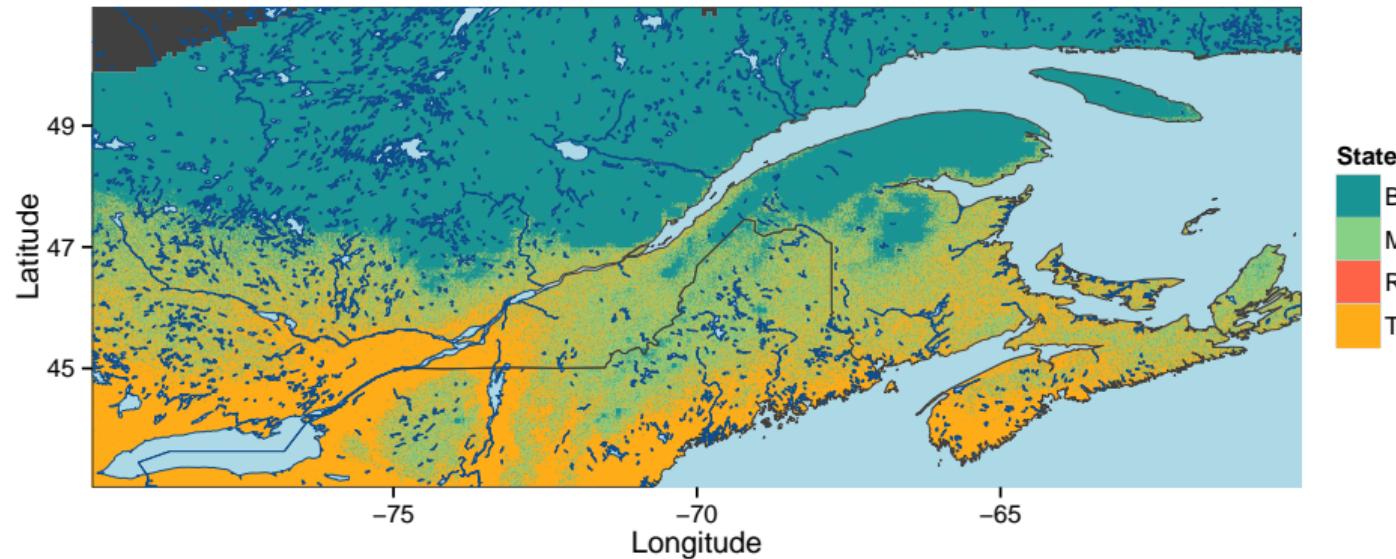
## SIMULATIONS PREDICT THE NEXT TIMESTEP



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## RESULTS PREDICT THE CURRENT LANDSCAPE

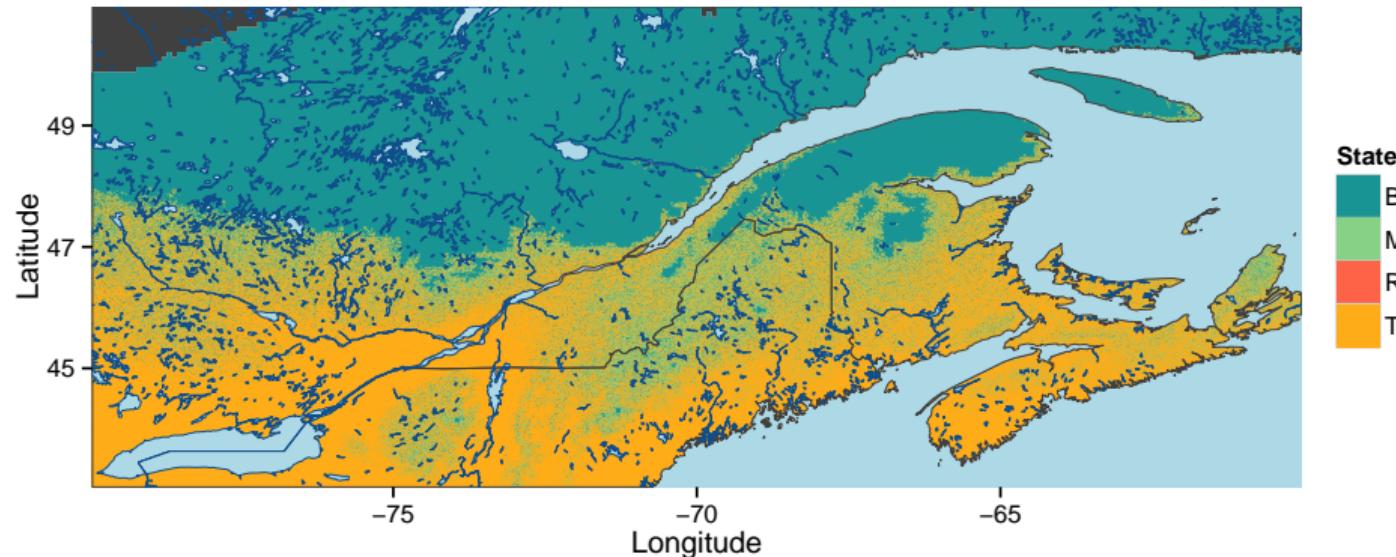
Current states distributions predicted on climatology: 1970-2000



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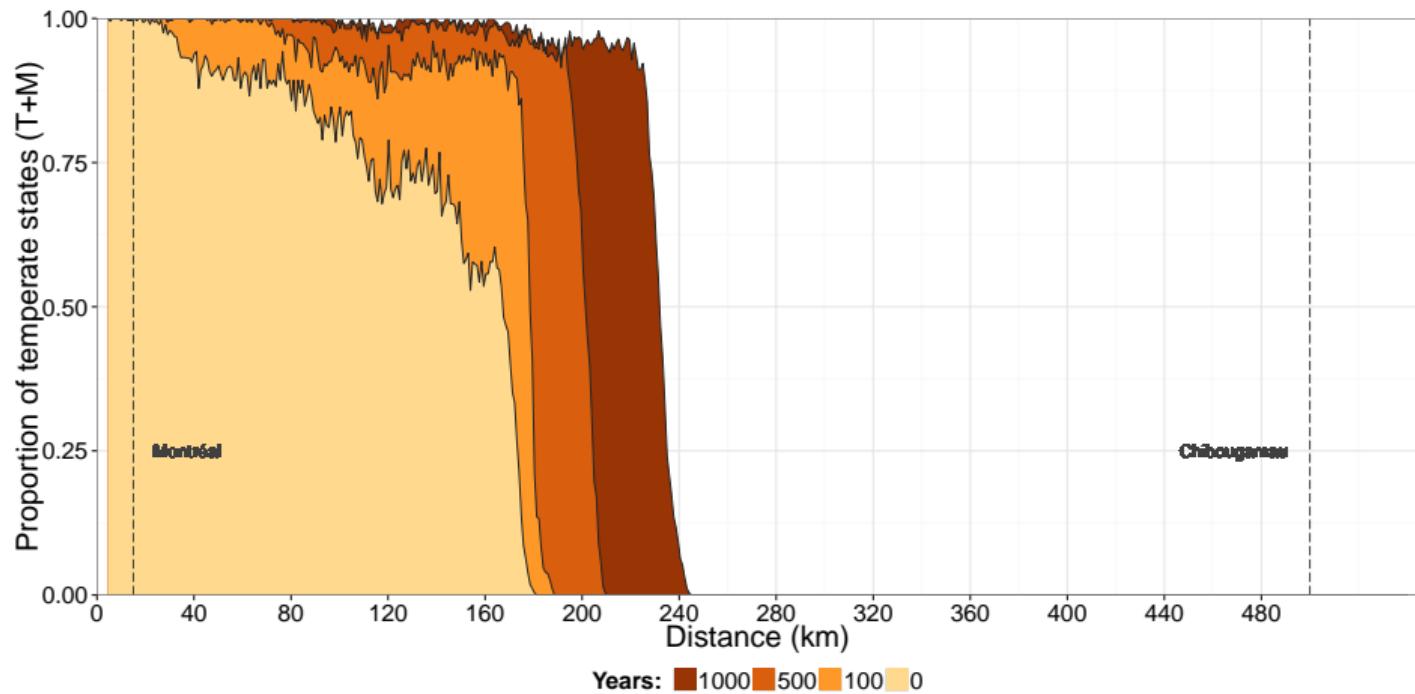
## RESULTS PREDICT THE CURRENT LANDSCAPE

Temperature increase linearly ( $4^{\circ}\text{C}$ ): 2100



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## RESULTS MIGRATION RATE PREDICTED



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## 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)

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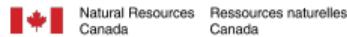
## ACKNOWLEDGEMENTS



Funded by



In collaboration with

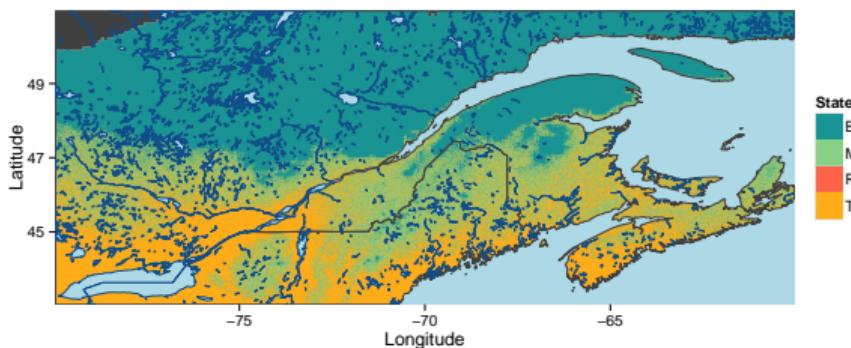


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## CALIBRATION EXTRA SLIDES

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

Landscape predicted by the STM



Bioclimatic domains in Quebec

