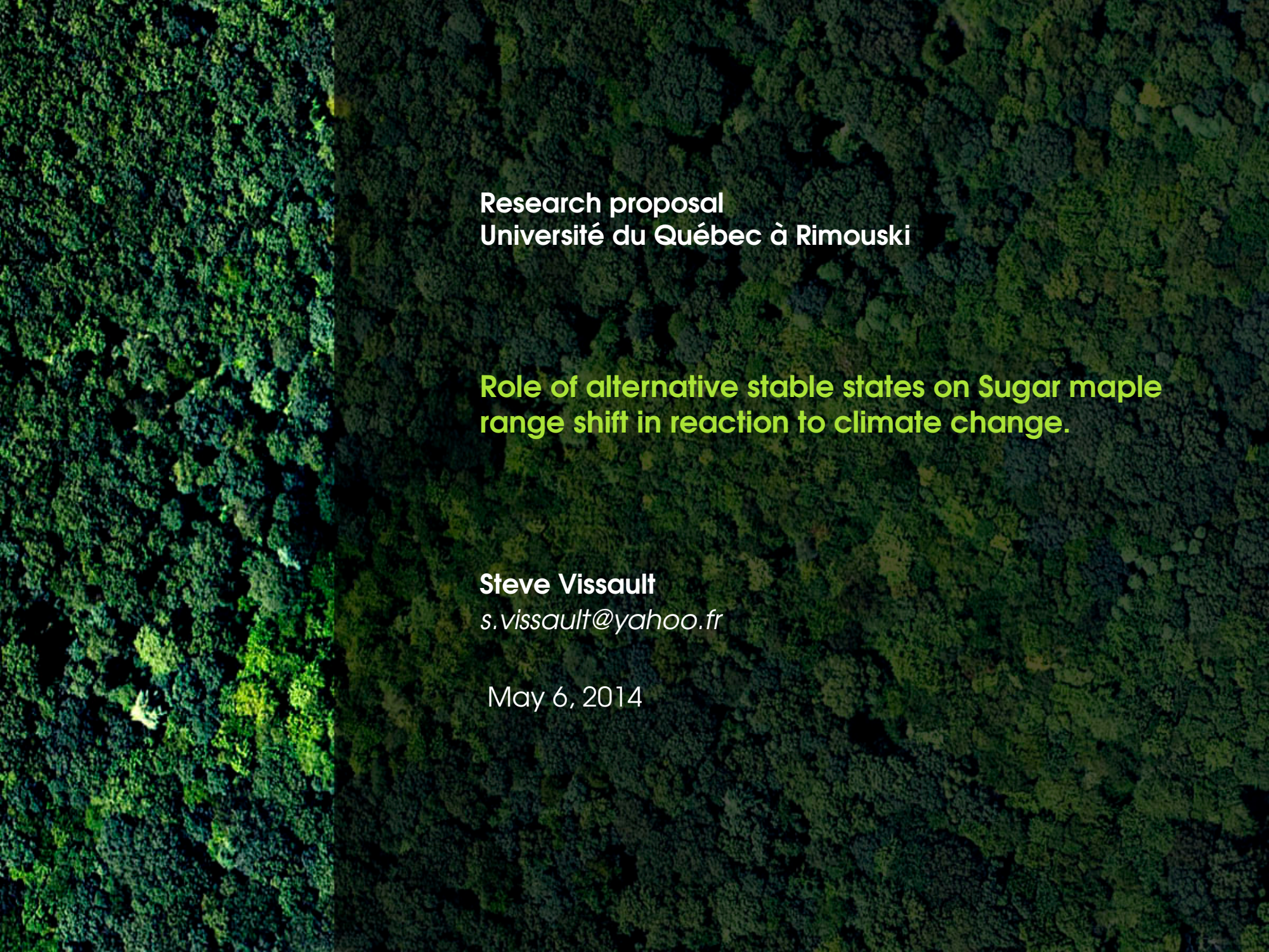


Research proposal
Université du Québec à Rimouski

Role of alternative stable states on Sugar maple range shift in reaction to climate change.

Steve Vissault
s.vissault@yahoo.fr

May 6, 2014

Table of content

Master proposal presentation

Sugar maple

Family Sapindaceae

Genus *Acer*

Species *saccharum*

Sugar maple

Family Sapindaceae

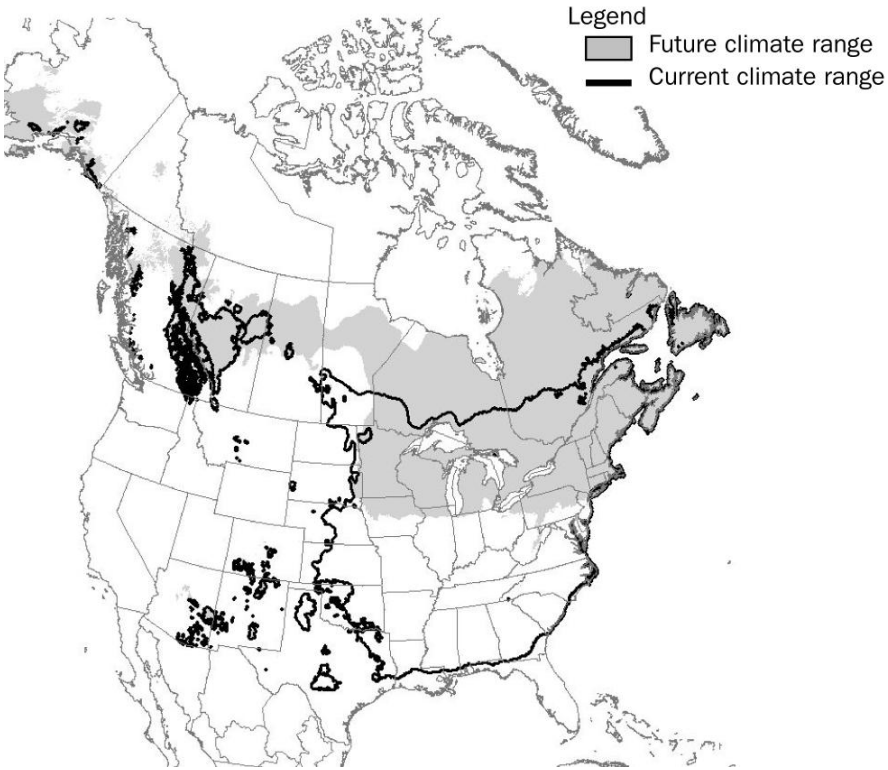
Genus *Acer*

Species *saccharum*

Prime economic importance in many regions of Quebec (e.g hardwood harvesting, syrup producer)

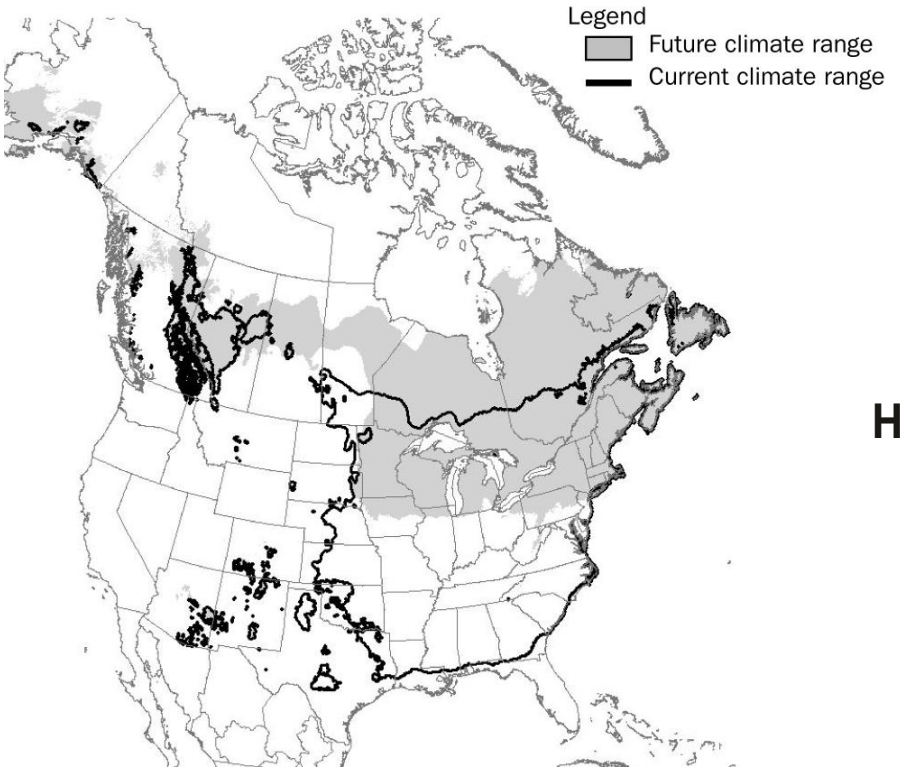
Goldblum and Rigg (2010)

Northern range limit of **Sugar maple** corresponds to the **upper boundary of the ecotone**.



McKenney et al. (2007)

- Distribution of maple sugar is coming to shift northward
- Reach the Ungava bay within the next 100 years



McKenney et al. (2007)

- Distribution of maple sugar is coming to shift northward
- Reach the Ungava bay within the next 100 years

Highly improbable:

1. Dispersal limitations
2. Slow population dynamic
3. SDMs accounting only climatic conditions

Sugar maple regeneration depends both on macro (i.e. regional climate) and **micro environmental conditions** (i.e. soil)

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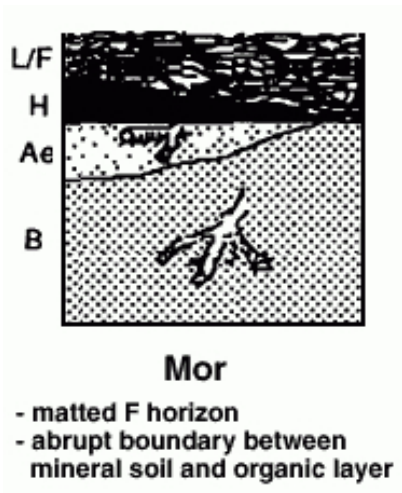
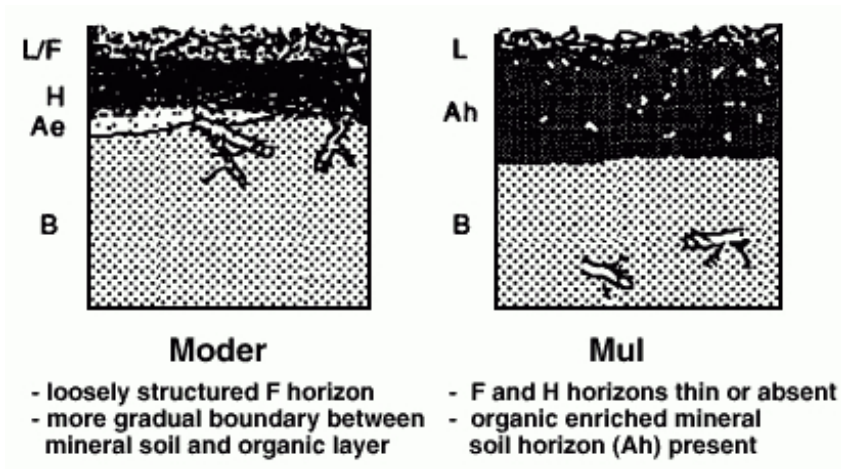
Boreal forest

Northern temperate forest

Boreal forest



Northern temperate forest



Lavender et al. (1990)

Goldblum and Rigg (2010)

Moisaic landscape structured by the species community, where Sugar maple are present in the northern temperate forest.

Main objective: Investigate the role of alternative stable states in the transition between the boreal and temperate forests under different climate change scenarios.

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Specific hypotheses:

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Specific hypotheses:

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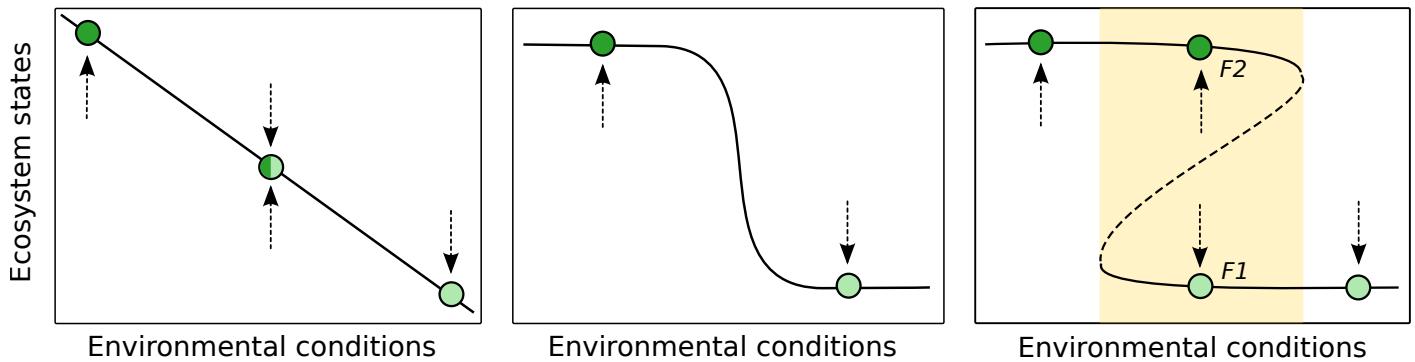
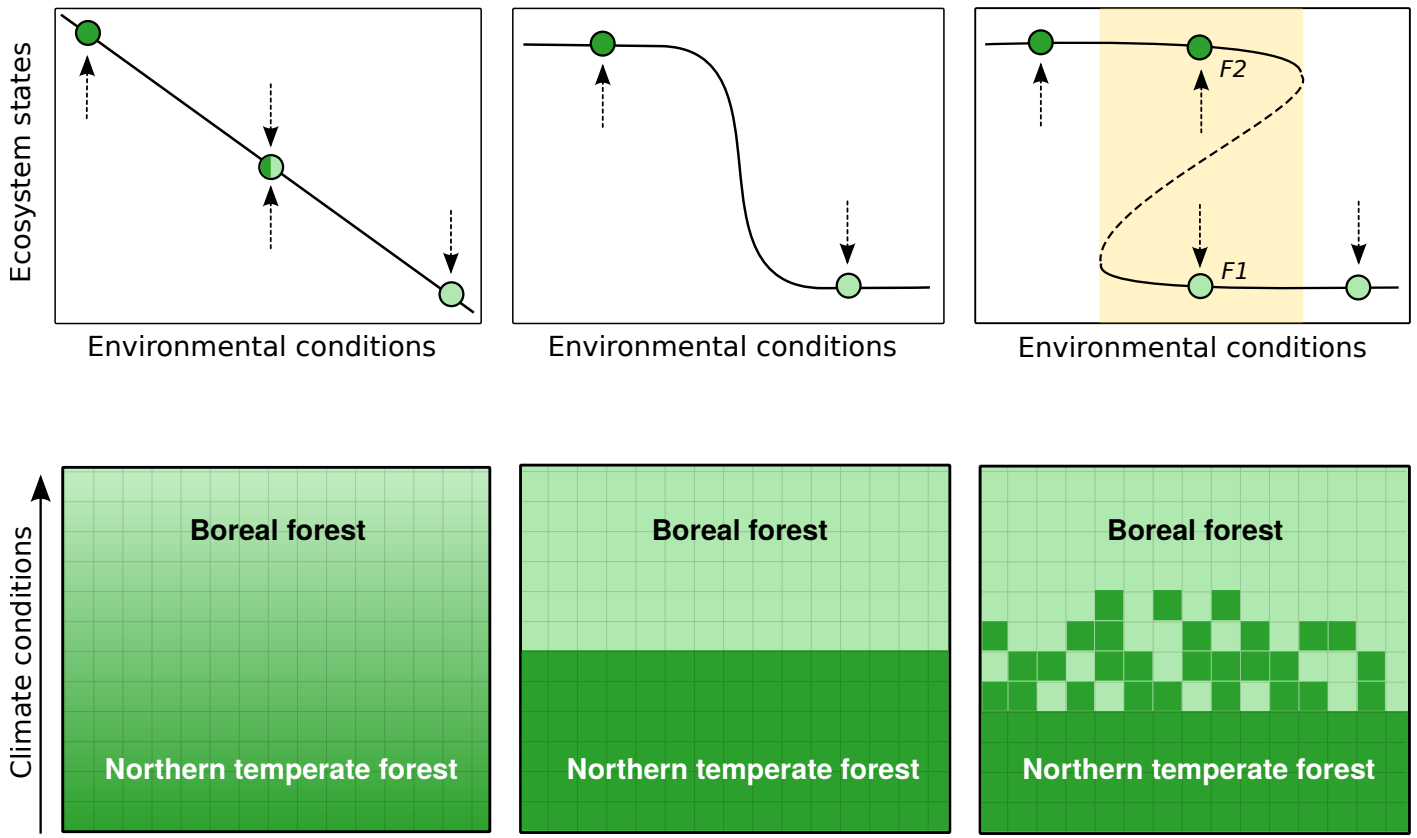
According to Scheffer (2009), alternative stable states mean a **contrasting states** to which a system may converge **under same external condition**


Ecosystem states
Environmental conditions
Environmental conditions
F2
F1
Environmental conditions


Ecosystem states
Environmental conditions
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Boreal forest
Northern temperate forest
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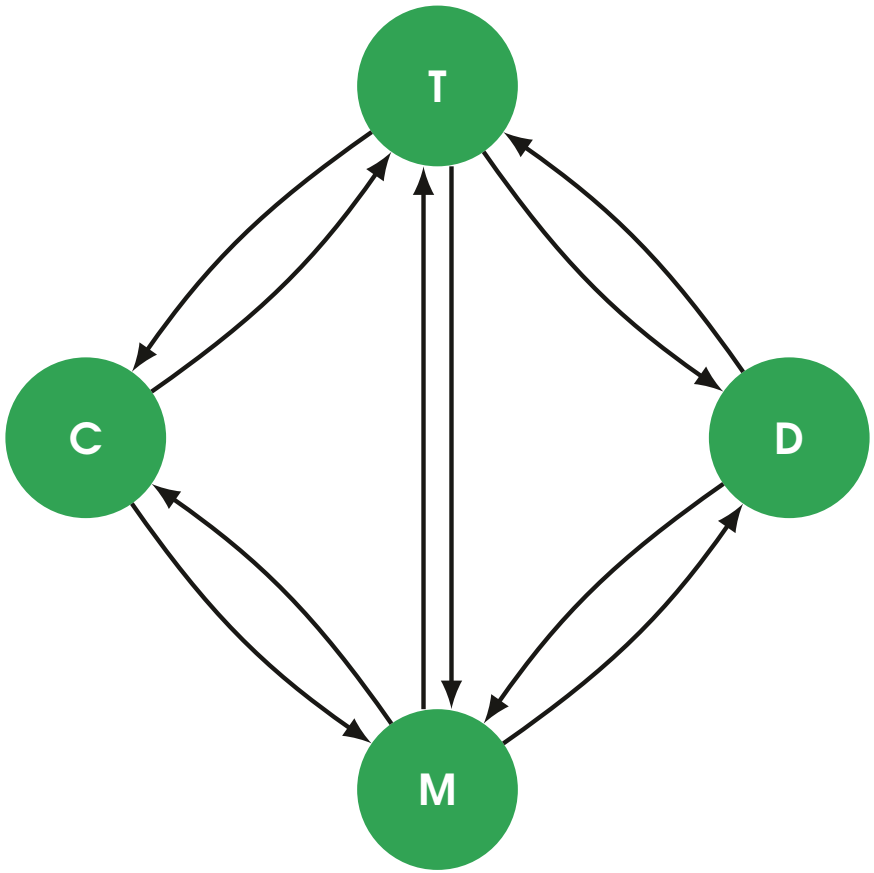
The Hypotheses:

H_1 **Alternative stable states** do co-occur at the boreal-temperate forests ecotone

H_2 Response of Sugar maple to climate change will be delayed in areas where **alternative stable states**are susceptible to occur

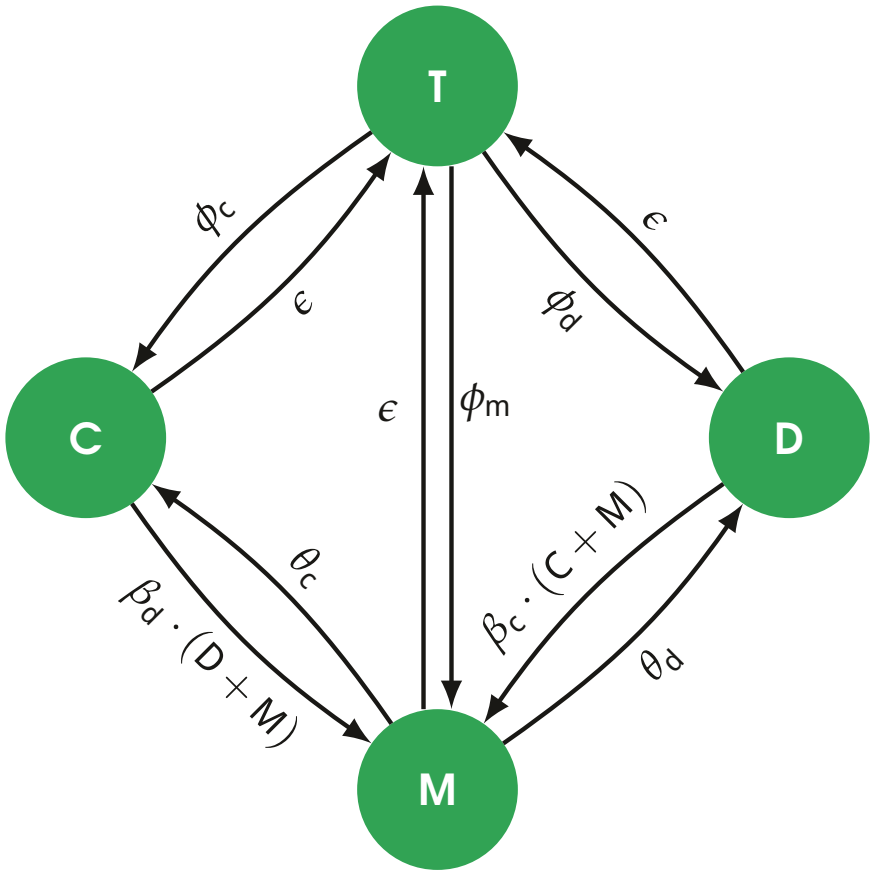
Which tool will be used to answer those hypotheses ?

We will use a State and Transitional Model (STM)



- Lanscape modelling scale
- 4 States (C,D,M,T)
- T correspond to a post-disturbance patch
- Probability of transition given climatic conditions
- Discrete time and stochastic model

We will use a State and Transitional Model (STM)



- β: Colonization rate
- θ: Succession rate
- ϕ: Regeneration functions
- ϵ: Disturbance rate.

Each rate depends:

- Proportion of states available in the system
- Climatic conditions encounter by the patch

Data structure:

- Permanent and temporary forest inventory sample plots (*ca.* 160,000 plots)
- 4 databases (USA,QC, ON, NB)
- Started in the 1970s
- Interval between sampling ranging from 5 to 10 years
- Stem-level information includes diameter at breast height (DBH), species.
- Climatic variables are associated to each plot (30 years previous to the year of measurement)

Data filters:

- 28 representative species of the whole dataset
- Only mature stands with dominant strata containing trees greater than 50 years old
- Plots with mesic soil conditions
- Plots no-disturbed by human activities (mostly by logging)

Calibration of the model will conduct only on permanent plot

The first calibration step is the plot classification:

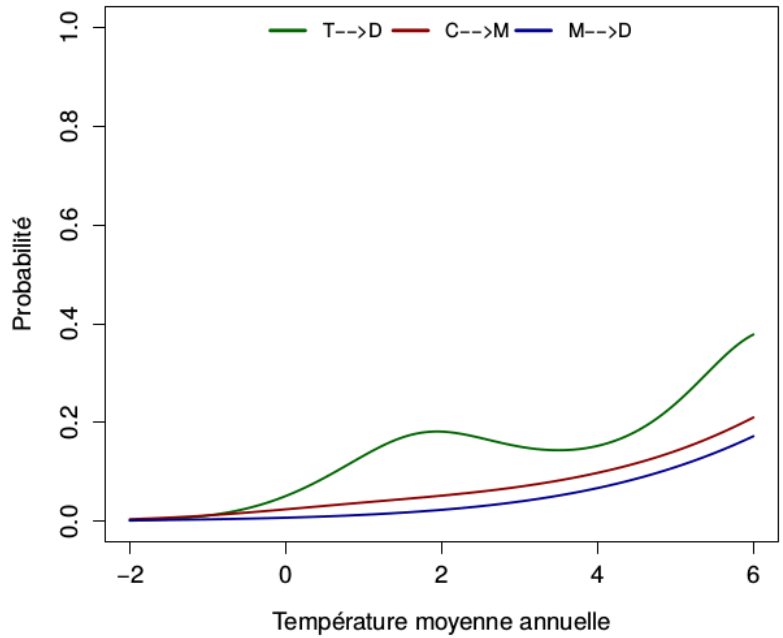
States	**Boundaries**
D	$Ba_d \geq 75\%$
C	$Ba_c \geq 75\%$
M	$Ba_c \geq 25\%$ and $Ba_d \geq 25\%$
T	$Ba_t \geq 75\%$

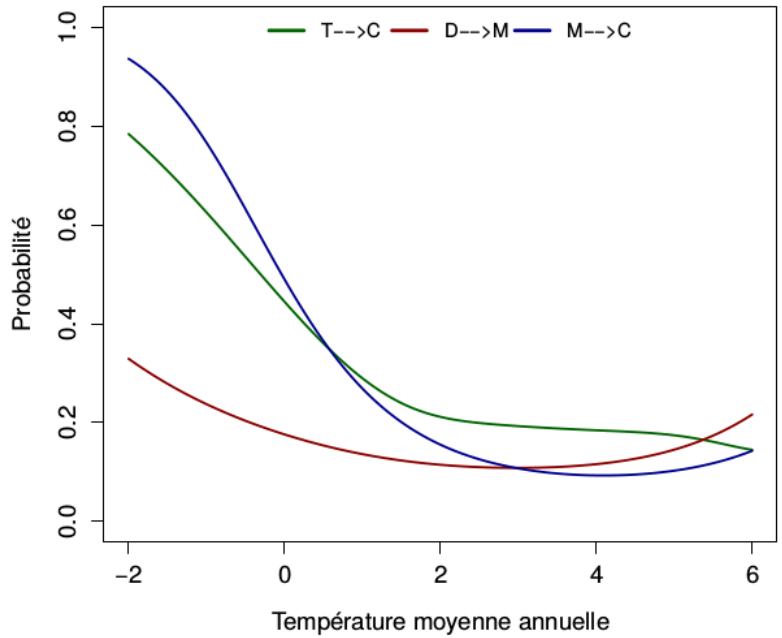
We will compute the probability functions,
with as example the transition of a patch D toward M:

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

Calibration

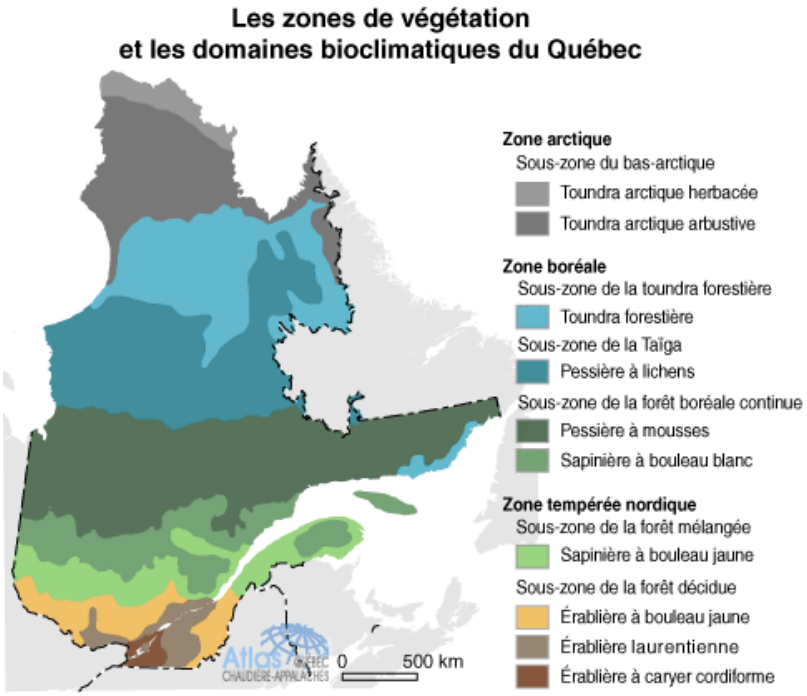
2. Compute probability functions





Validation

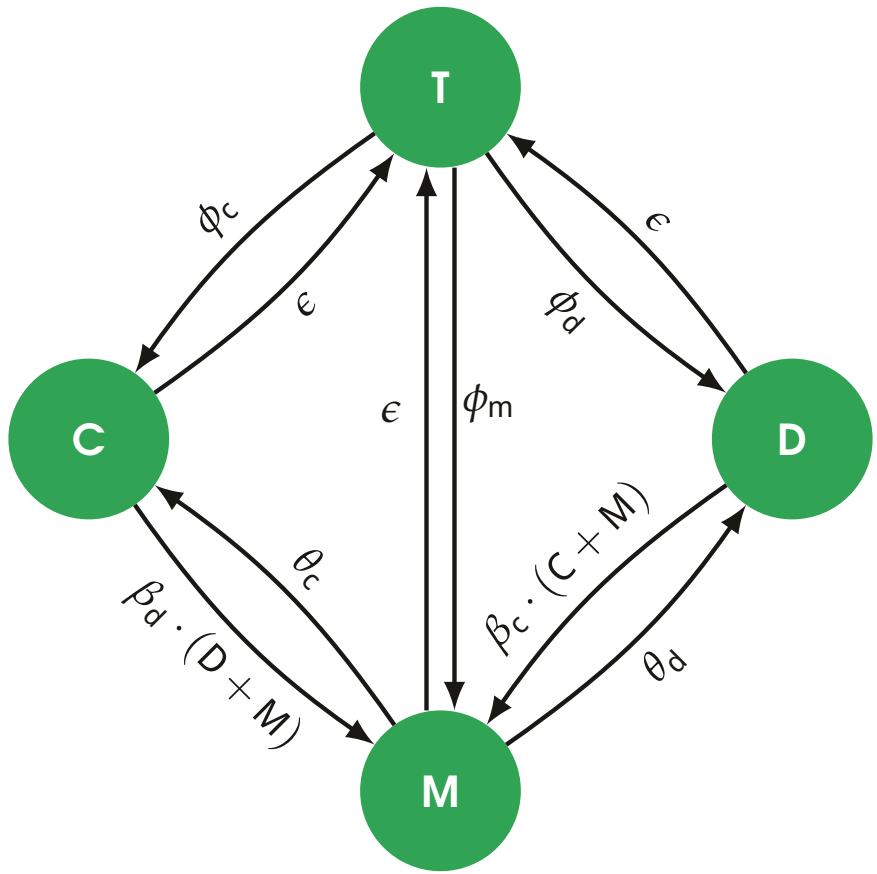
Cross validation with temporary plots



1. Classify temporary plots into the four states (C,D,M,T)
2. Compute the states proportion by ecoregions
3. Run the model previously calibrated
4. Compare state proportion predicted (PP) to state proportion realized (TP)

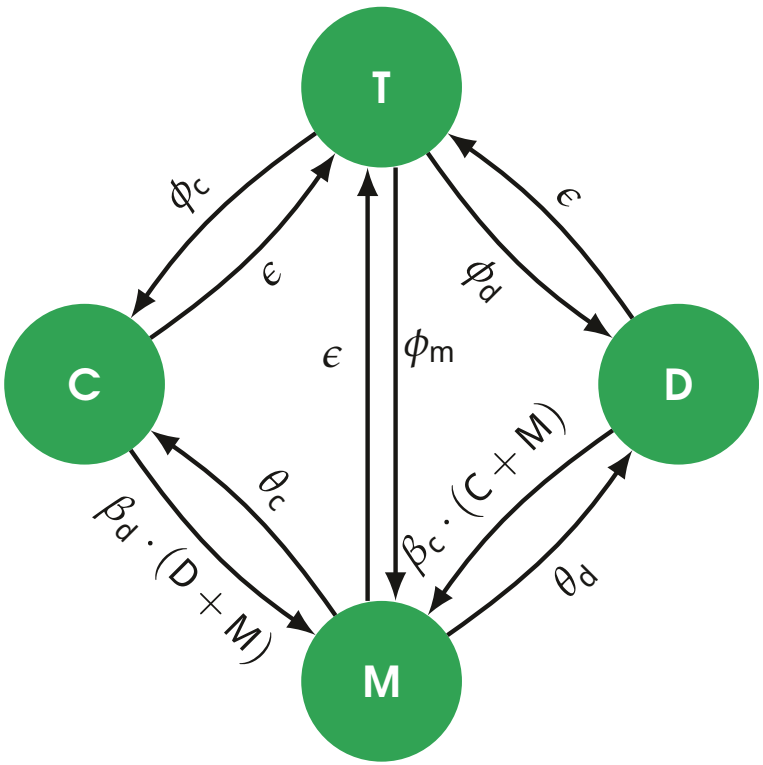
H_1 Alternative stable states do co-occur at the boreal-temperate forests ecotone

State and Transitional Model

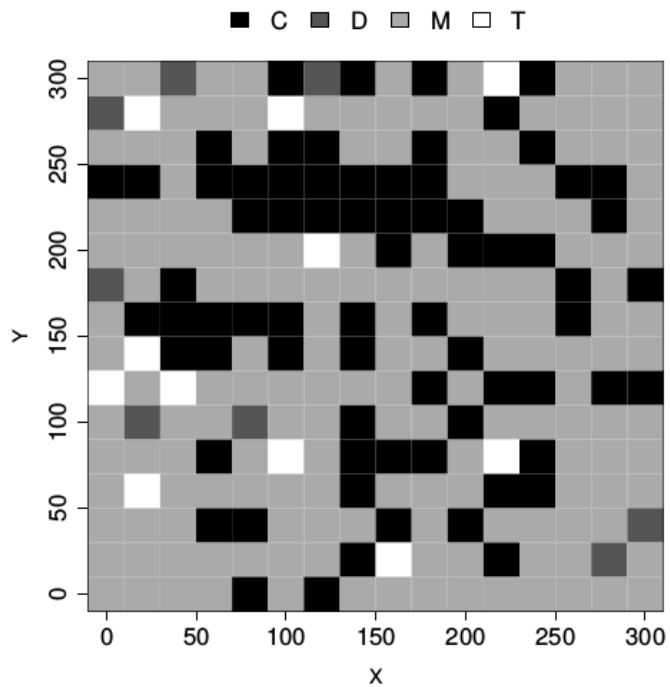


H_2 Response of Sugar maple to climate change will be delayed in areas where alternative stable states are susceptible to occur

State and Transitional Model



Cellular automata



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Thanks for your attention !

Any questions ?