



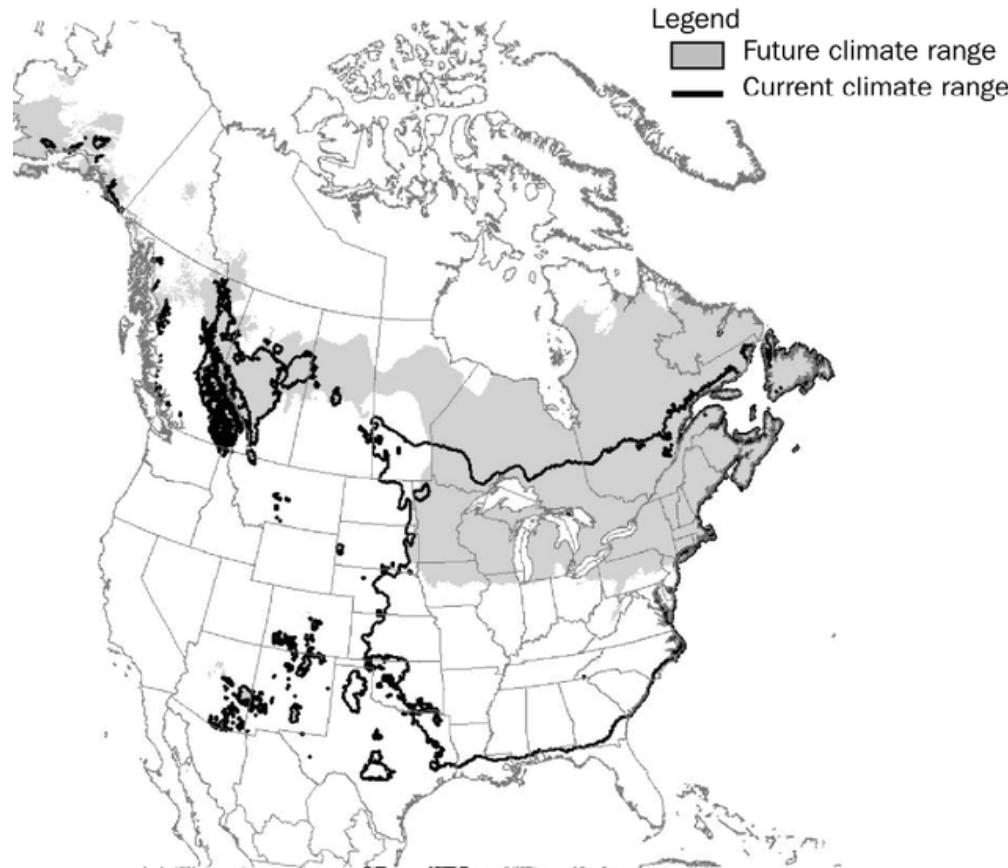
# Dynamique de transition des communautés forestières dans l'écotone boréal-tempéré

Marie-Hélène Brice, Pierre Legendre & Marie-Josée Fortin

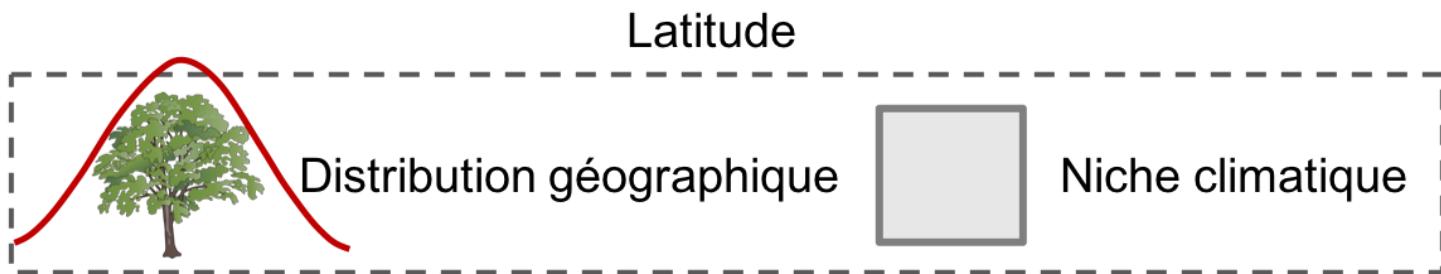
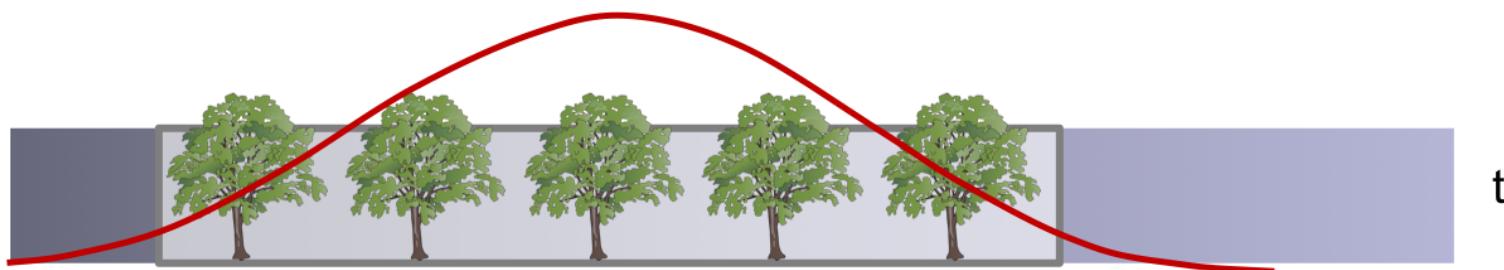


# Déplacement des niches

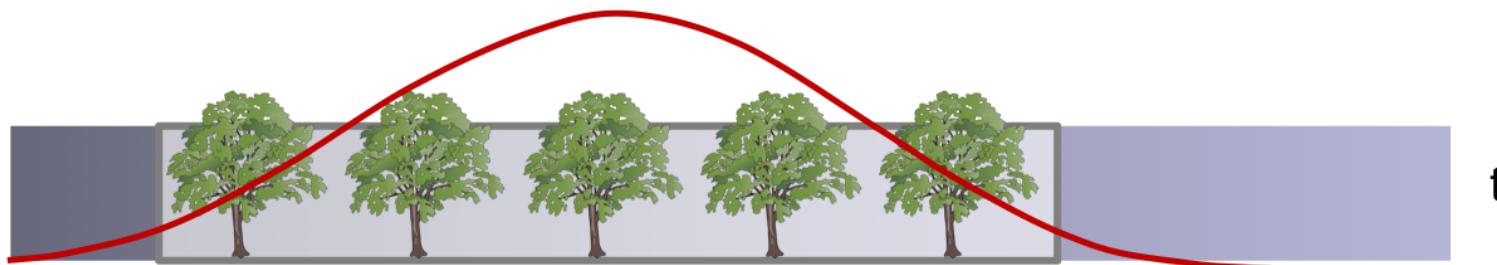
Future enveloppe climatique de l'Érable à sucre (2071-2100)



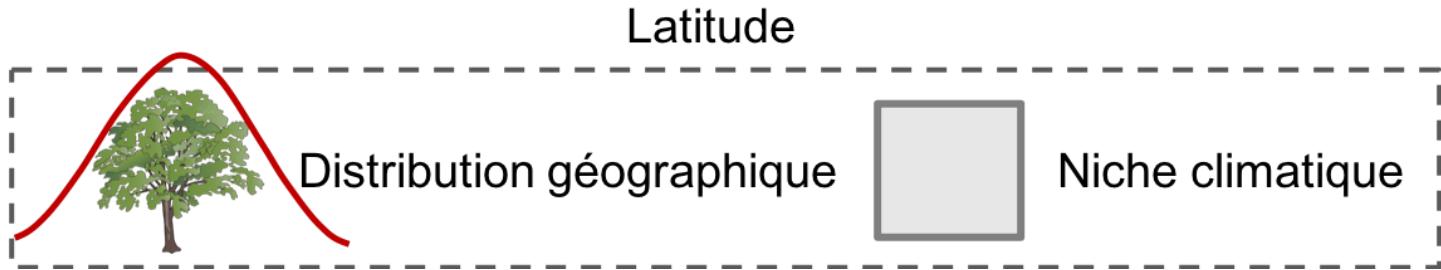
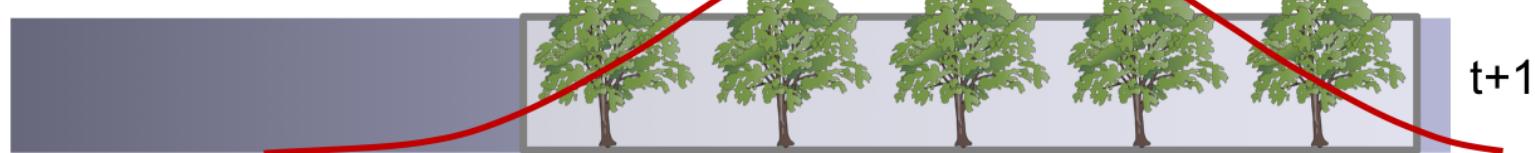
# Déplacement des niches



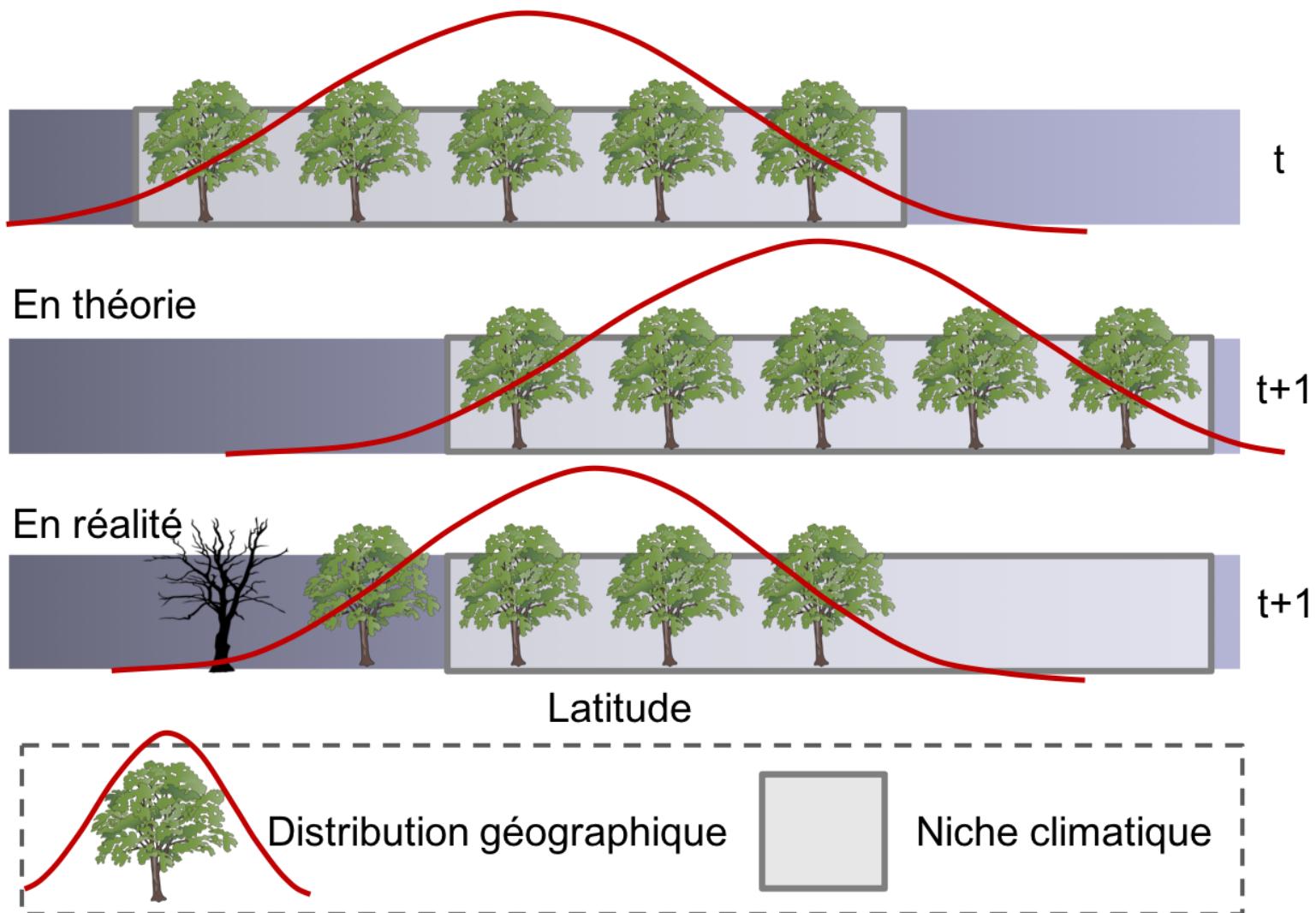
# Déplacement des niches



En théorie



# Déplacement des niches



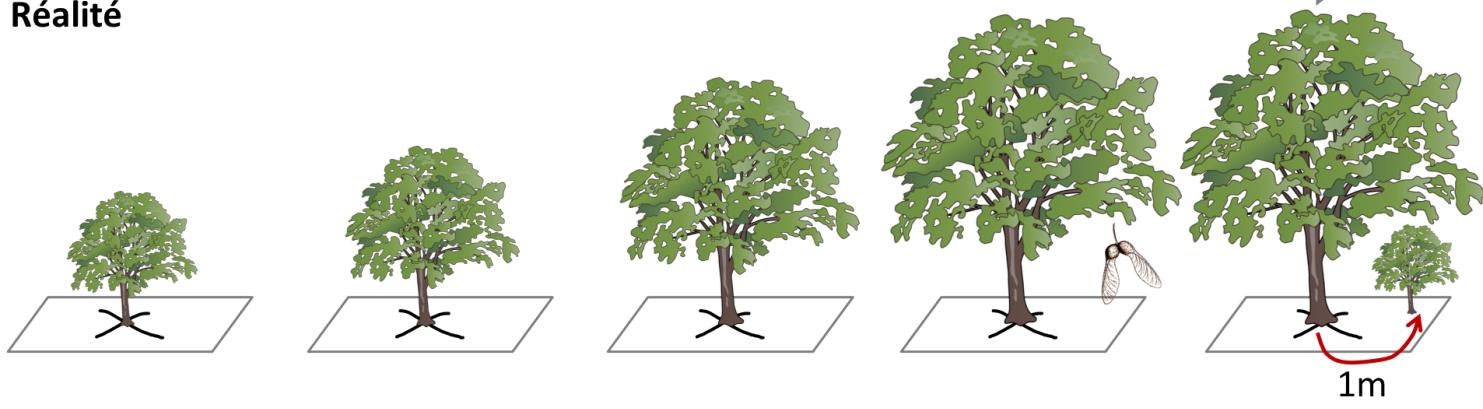
# Contraintes à la migration

- Démographie lente
- Dispersion limitée
- Compétition interspécifique

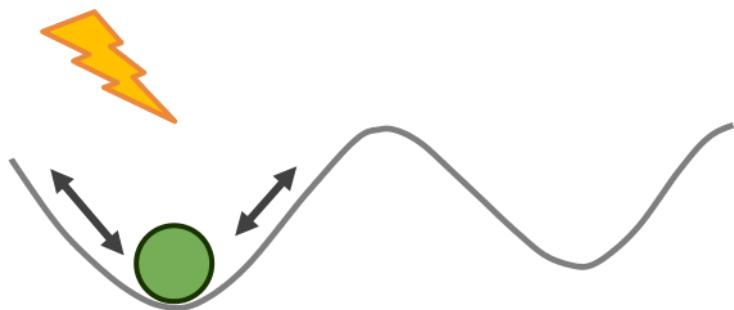
Prédiction



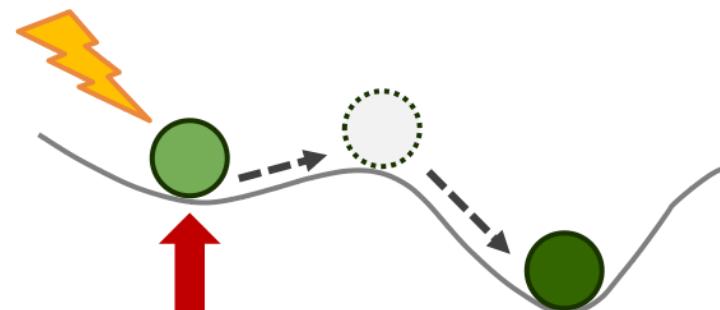
Réalité



# États alternatifs stables



Climat historique



Climat plus chaud

**État 1**  
Ex: forêt mixte

**État 2**  
Ex: forêt tempérée

**État 1**  
Ex: forêt mixte

**État 2**  
Ex: forêt tempérée



État de l'écosystème

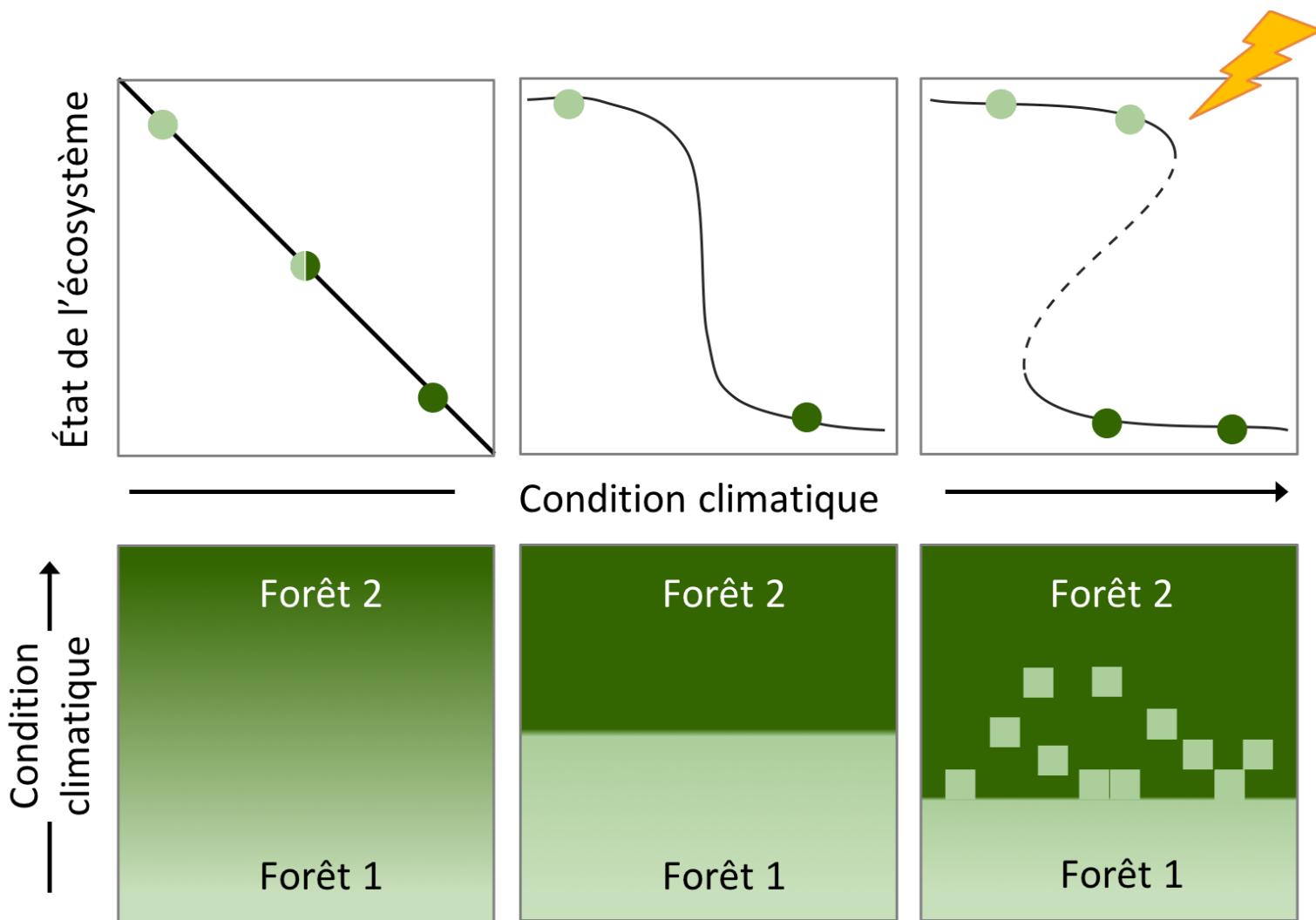


Perturbation



Domaine d'attraction

# Réponses des écosystèmes aux changements



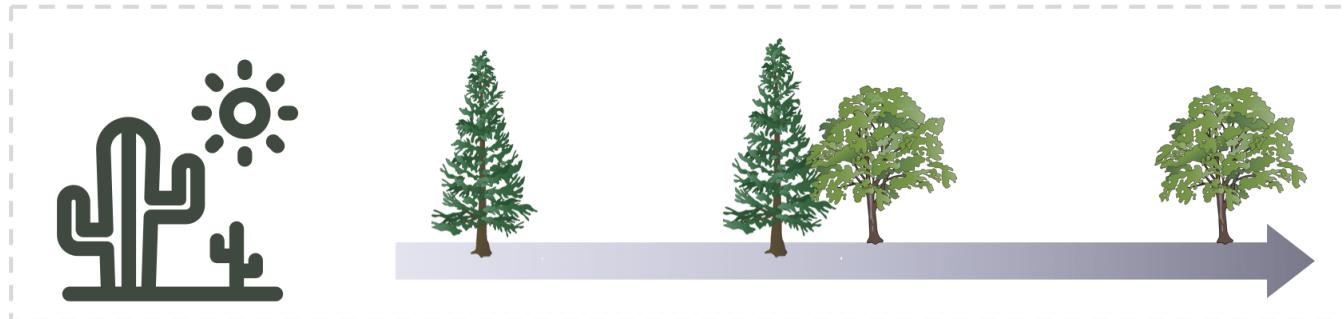
Scheffer & Carpenter 2003

## Comprendre les contraintes et les moteurs sous-jacents de la dynamique de transition des communautés forestières du Québec.

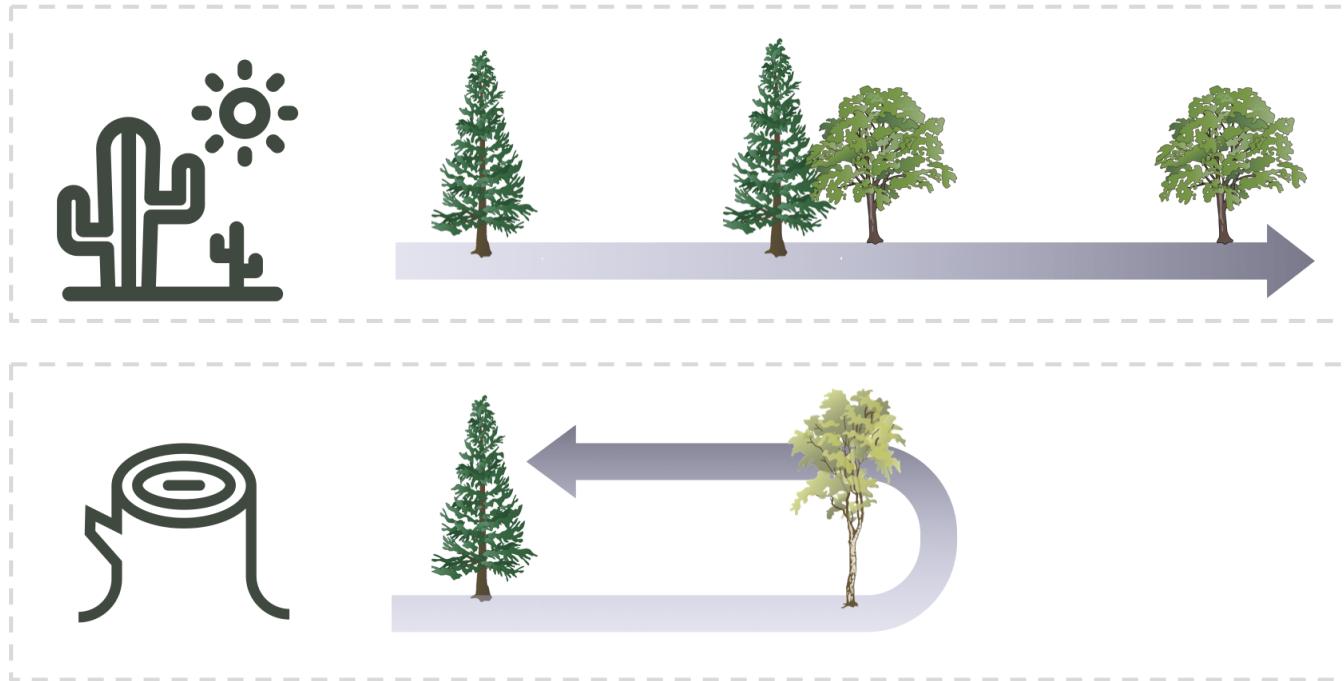
- ① Quelles ont été les transitions d'état dans les forêts au cours des dernières décennies?
- ② Quels facteurs environnementaux déclenchent ces transitions de communautés?
- ③ Est-ce que les perturbations peuvent accélérer certaines transitions?



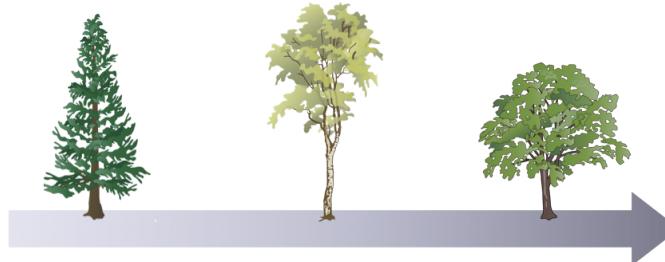
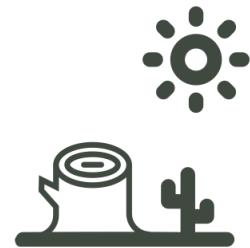
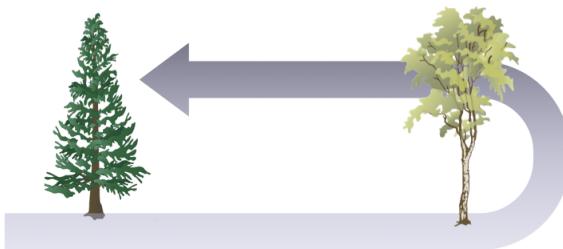
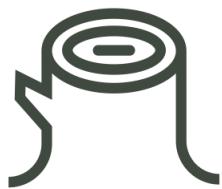
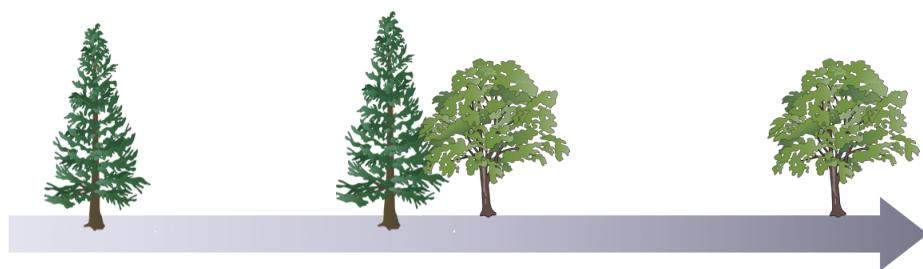
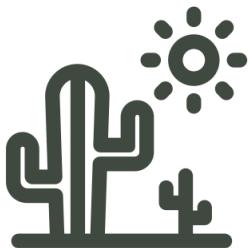
# Hypothèses



# Hypothèses



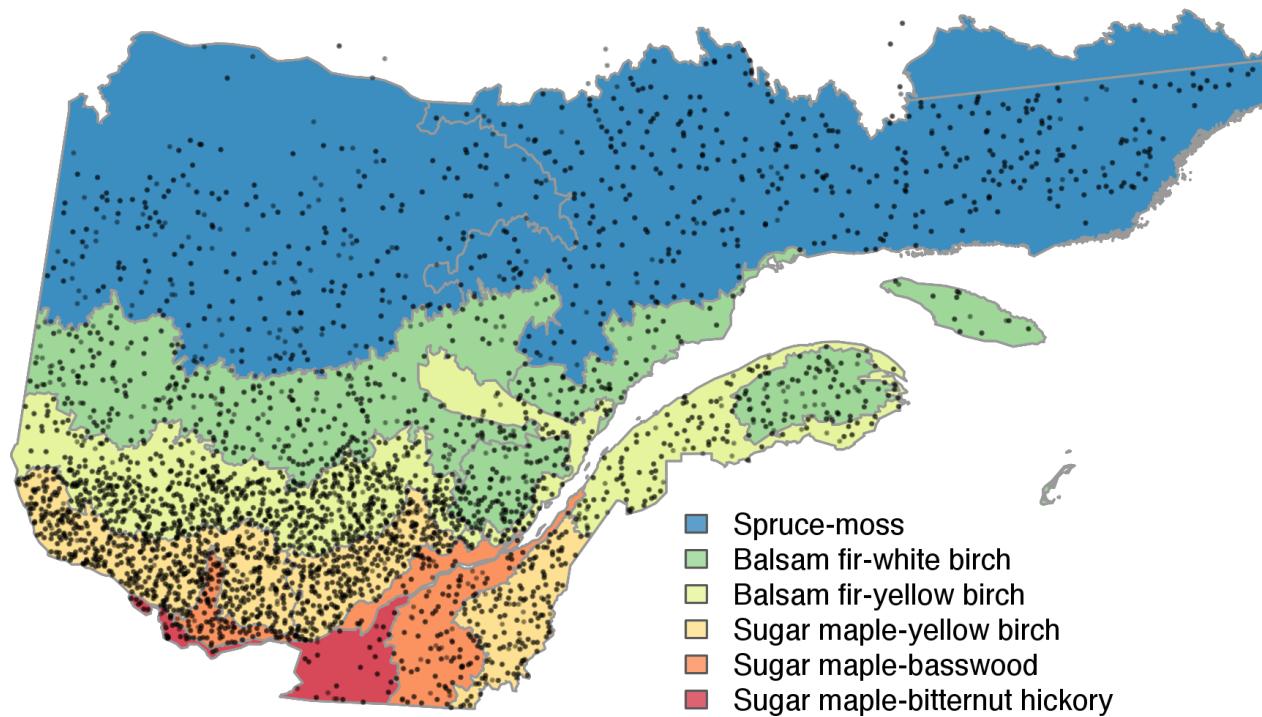
# Hypothèses



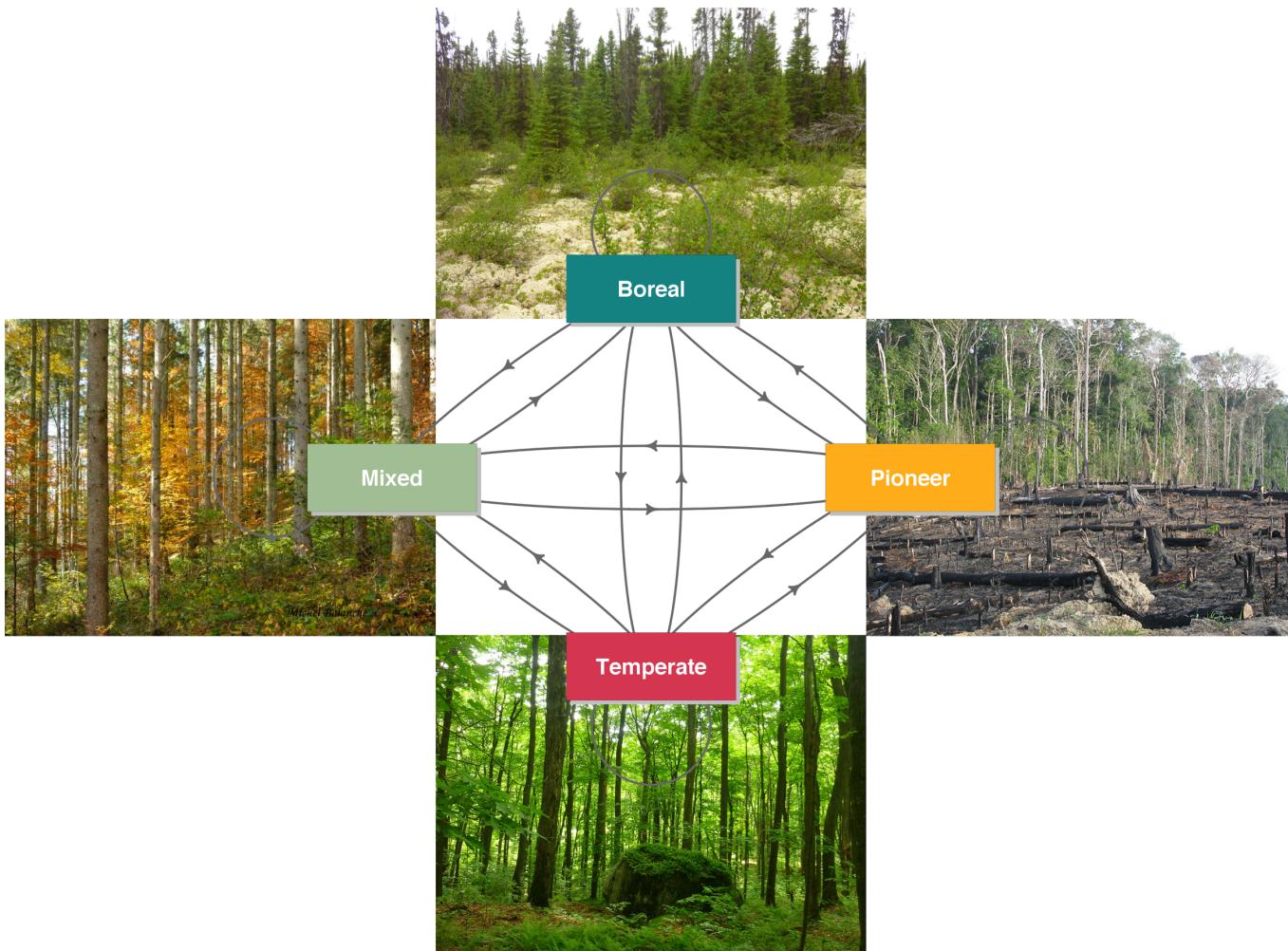
# Données

## Inventaires forestiers du Québec Méridional

- 12000+ parcelles permanentes échantillonnées durant 5 grands inventaires entre 1970 et 2016 (par le MFFPQ)
- Sélection de 6381 parcelles inventoriées au moins 2 fois chacune

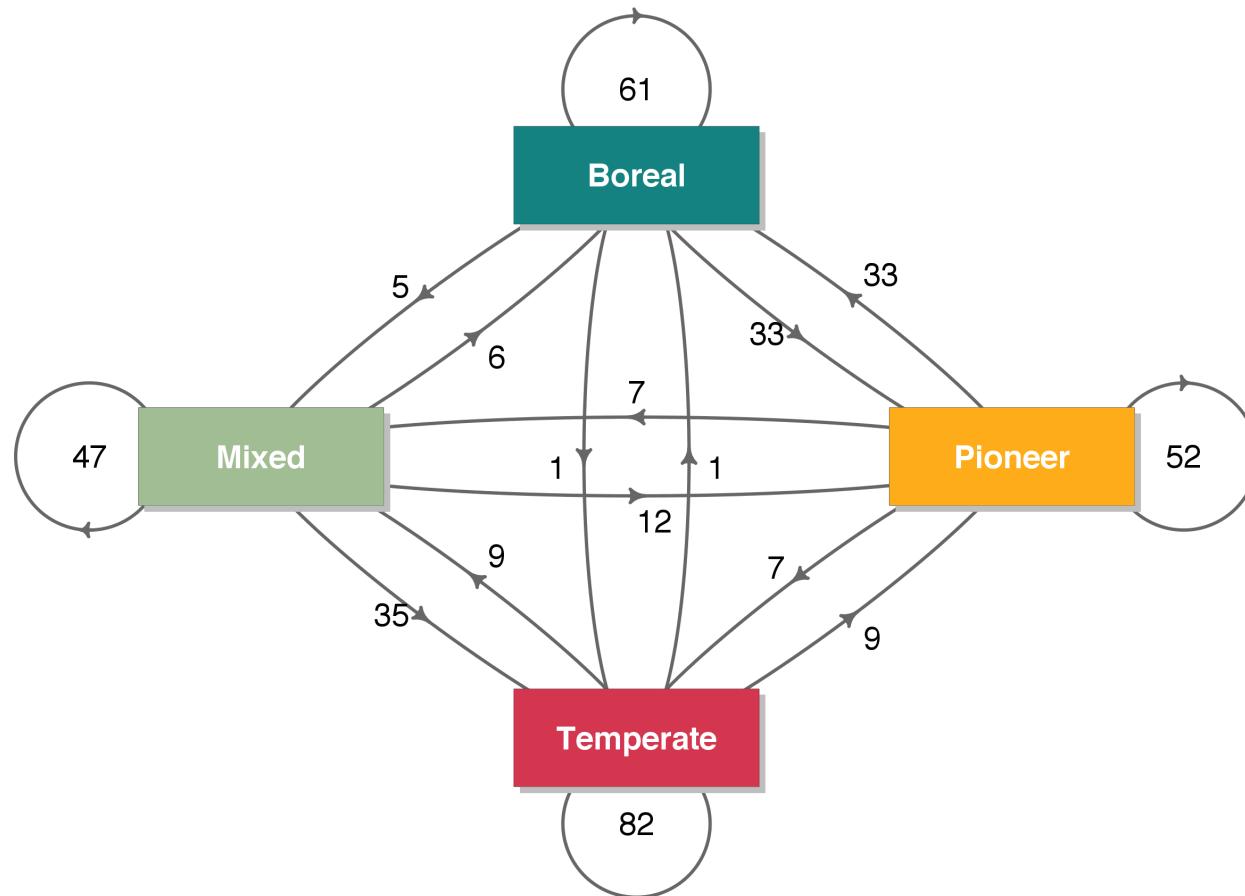


# Données

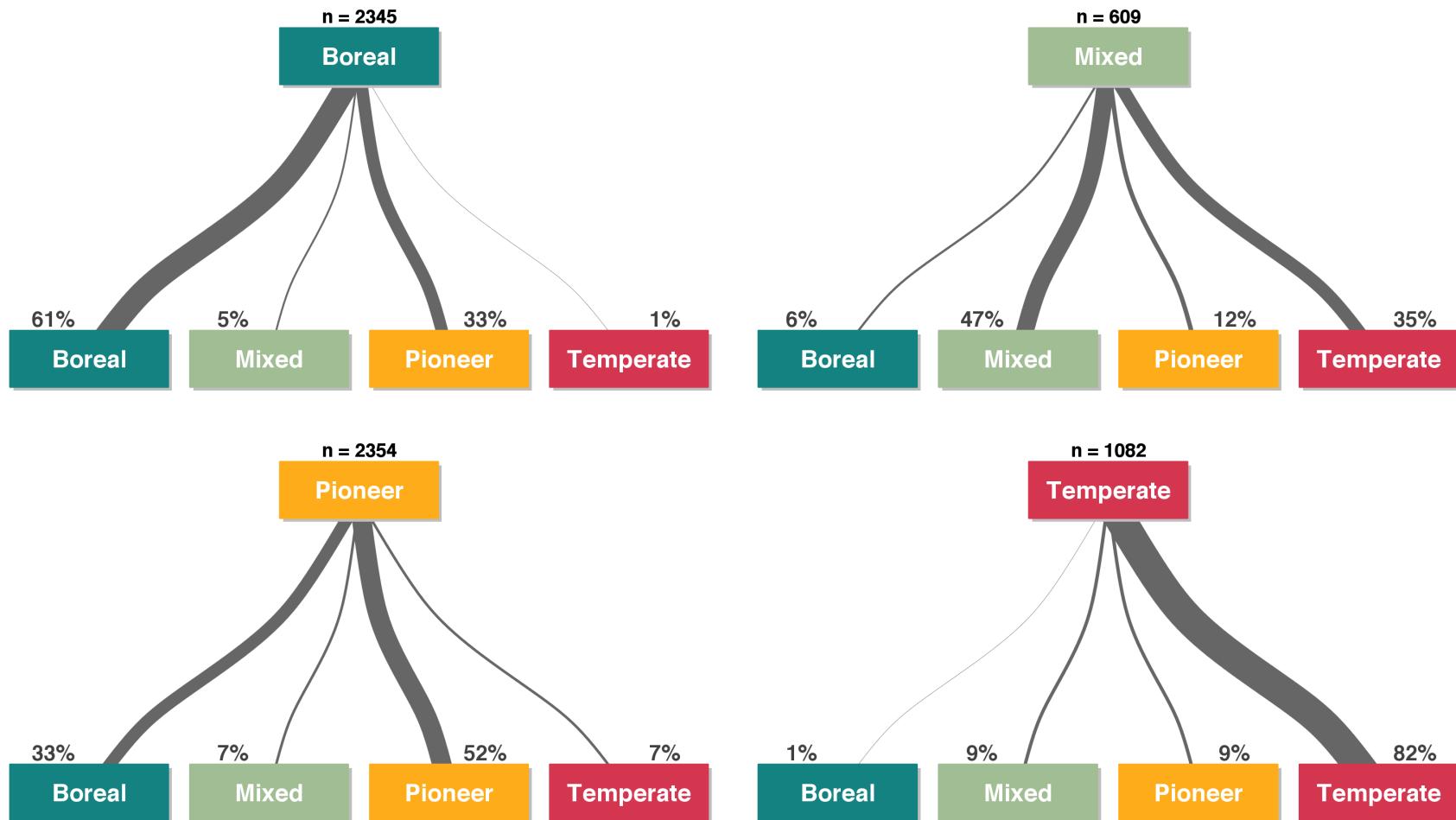


# Transitions observées

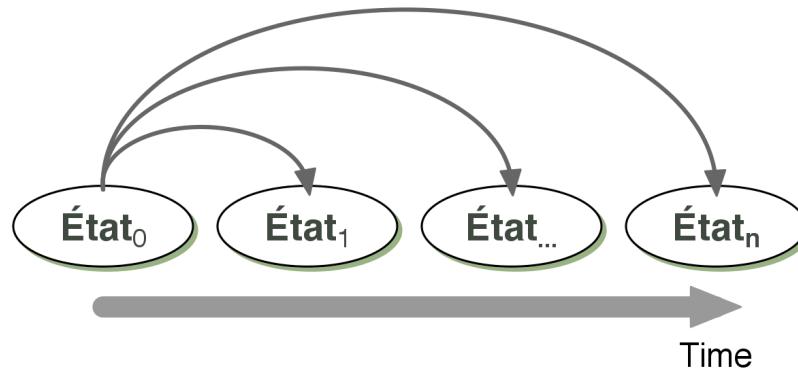
Probabilité de transitions entre le premier et le dernier inventaire



# Transitions observées

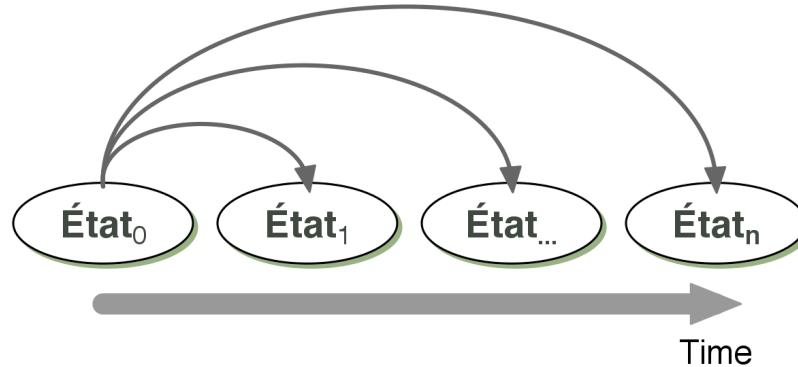


# Modèle de transition



$$P(Etat_0 = j | Etat_n = i, Climat, Perturbation, Local)$$

# Modèle de transition

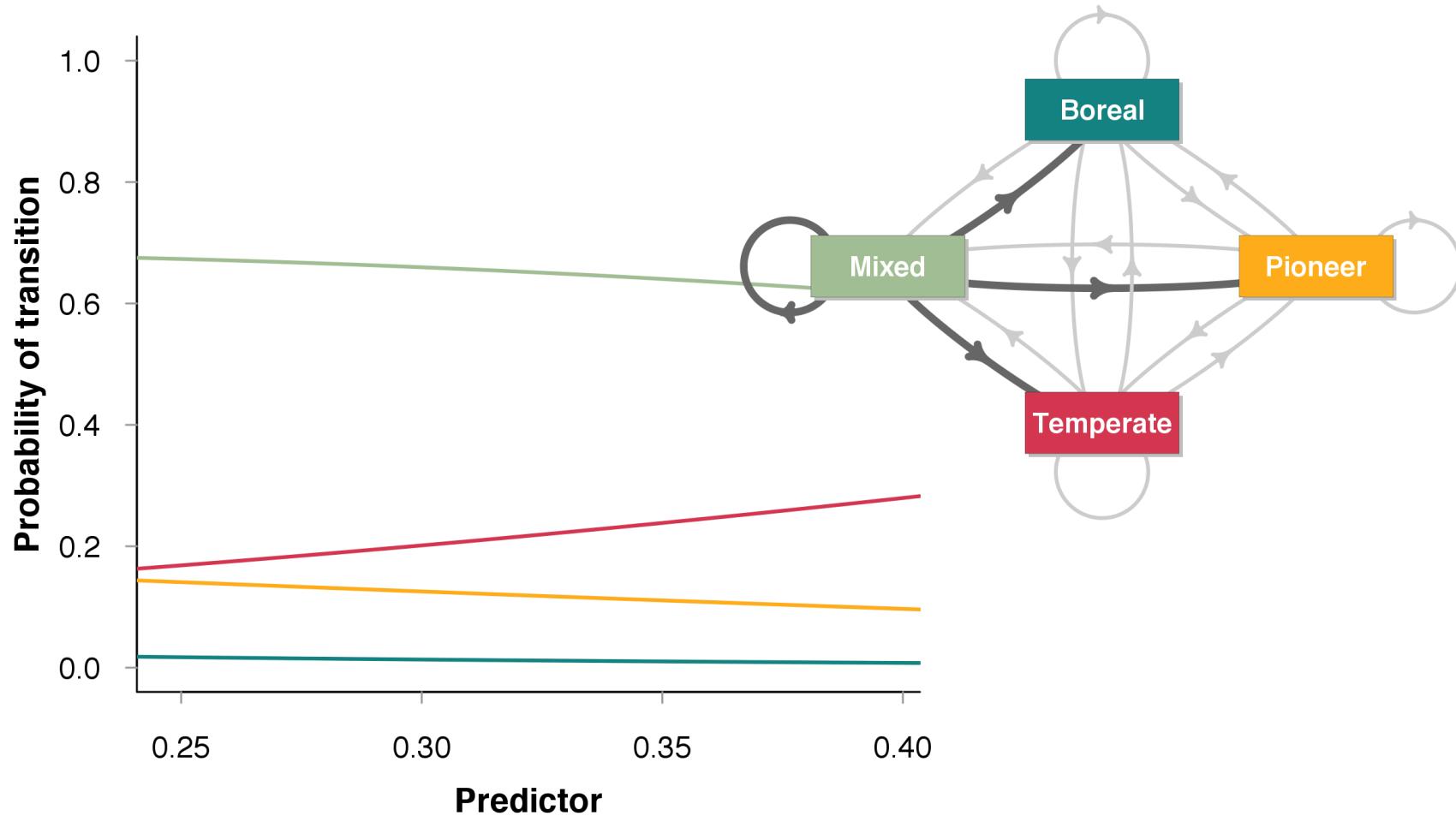


$$P(Etat_0 = j | Etat_n = i, Climat, Perturbation, Local)$$

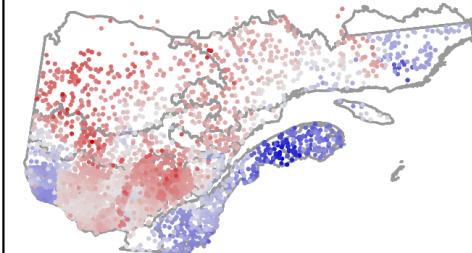
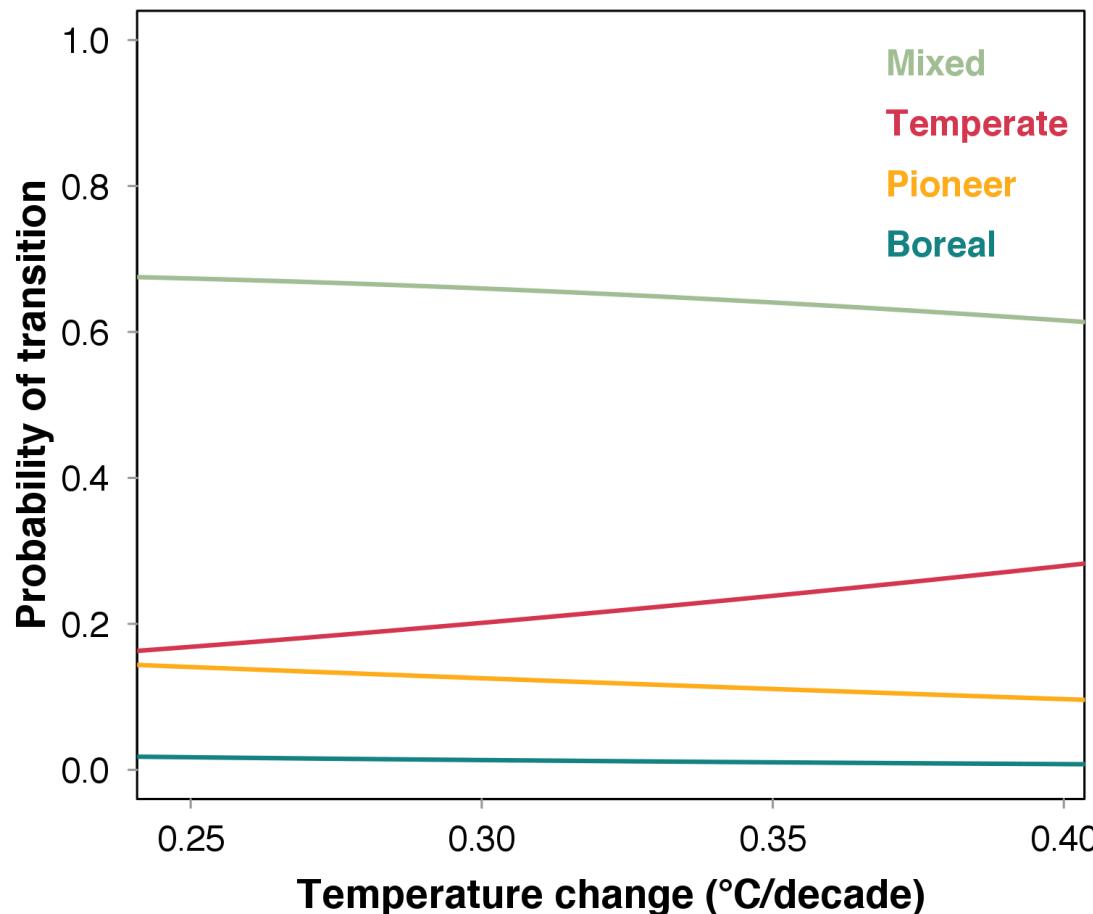
Chaque probabilité de transition dépend de:

Climat	Perturbations	Local & voisinage
🌡️ Température à $t_1$	🔥 Perturbations naturelles	🌐 Domaines bioclimatiques
🌧️ Précipitation à $t_1$	🪞 Coupes	⼟ Type de sol
〽️ $\Delta$ Température/an	👤 Âge du peuplement	⌚ Années depuis $t_1$
〽️ $\Delta$ Précipitation/an		

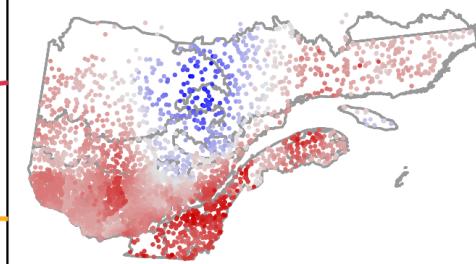
# Déclencheurs des transitions



# Influence du changement climatique



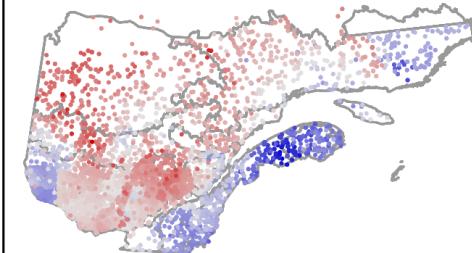
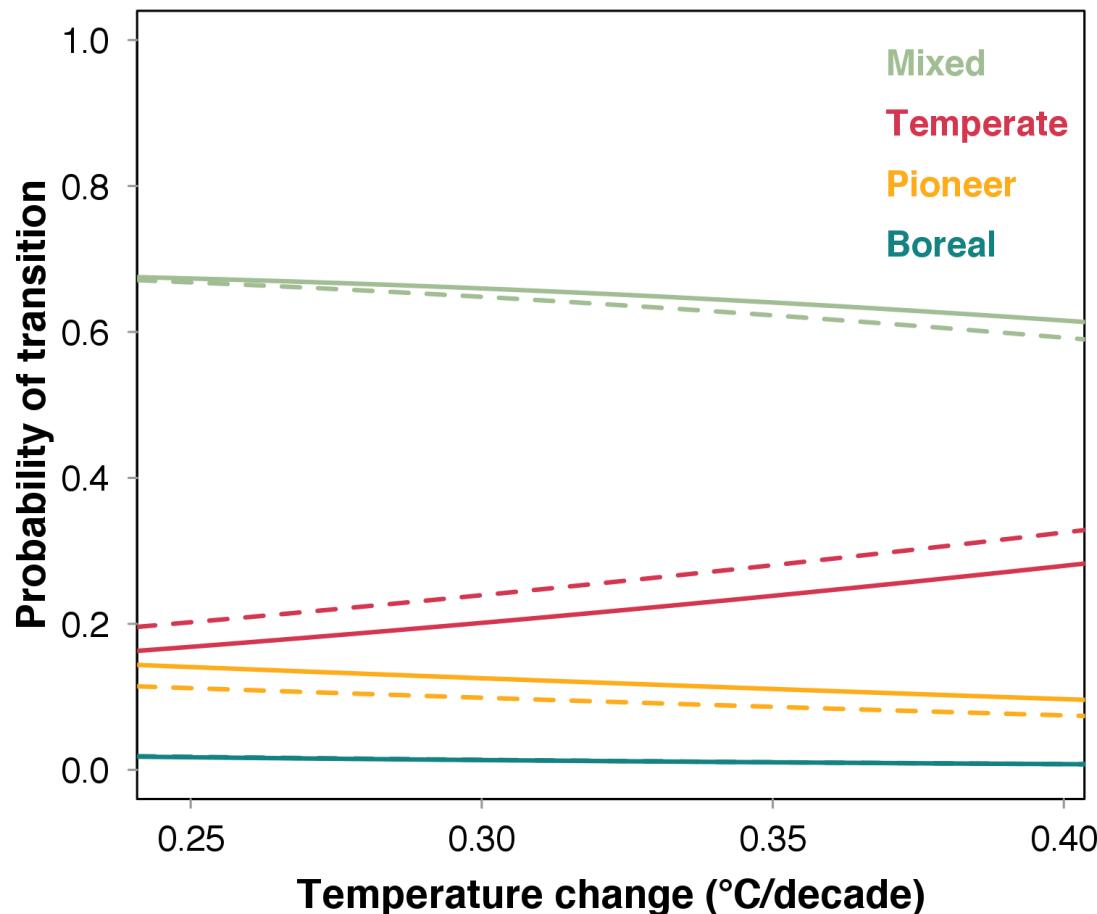
Temperature change



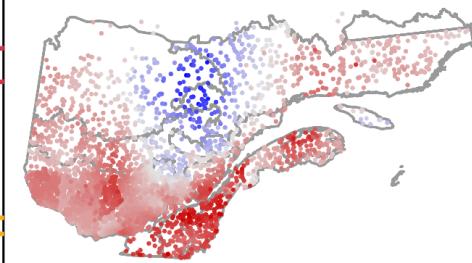
Precipitation change

- Small decrease in precipitation (-1mm/decade)
- Moderate increase in precipitation (+11mm/decade)
- - Large increase in precipitation (+30mm/decade)

# Influence du changement climatique



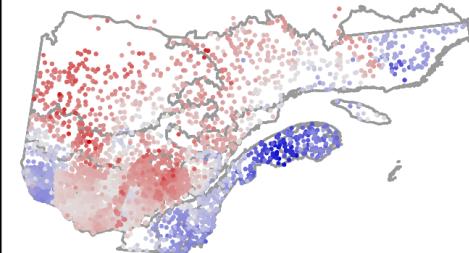
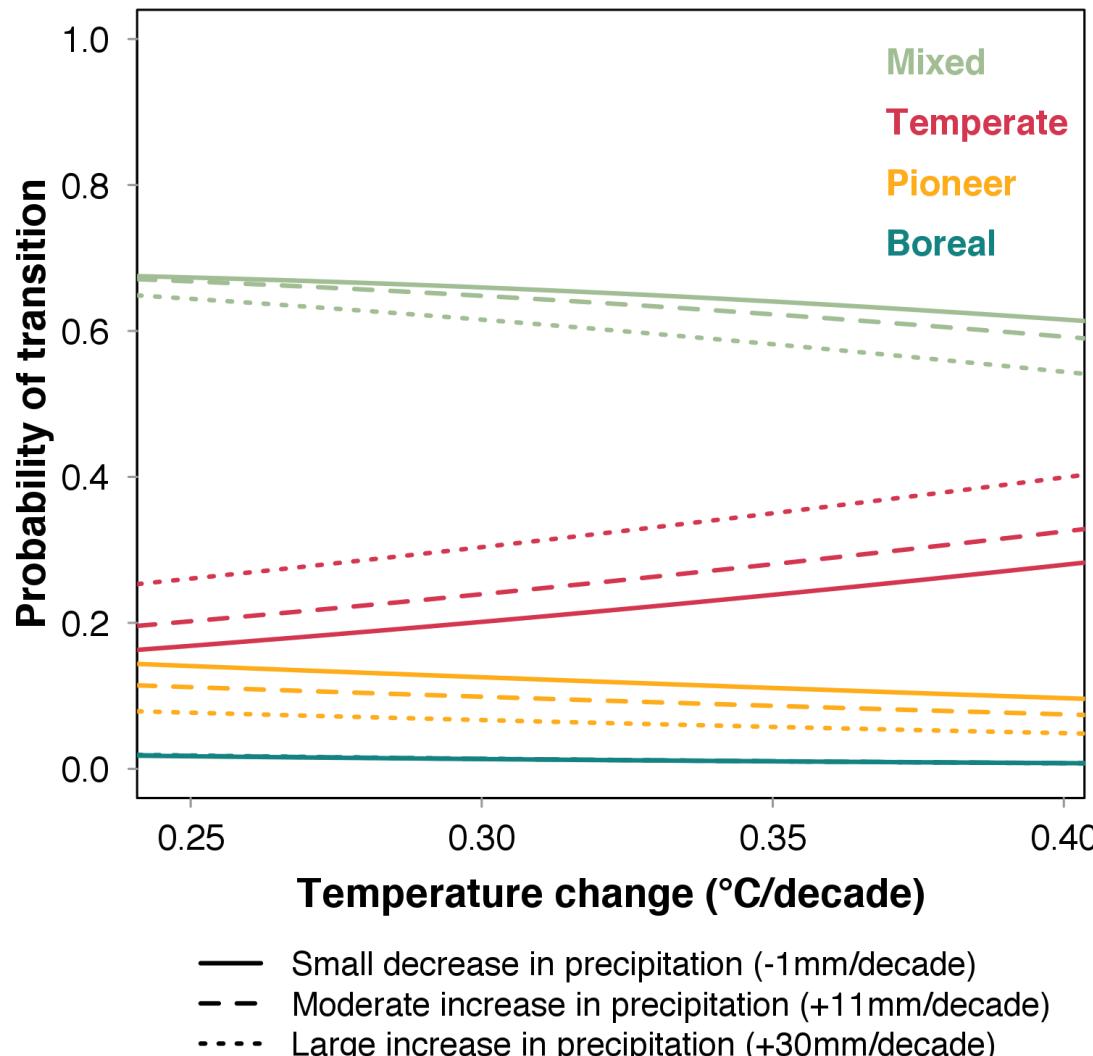
Temperature change



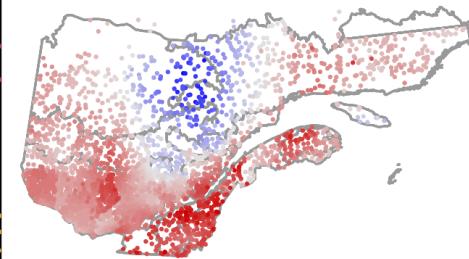
Precipitation change

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# Influence du changement climatique

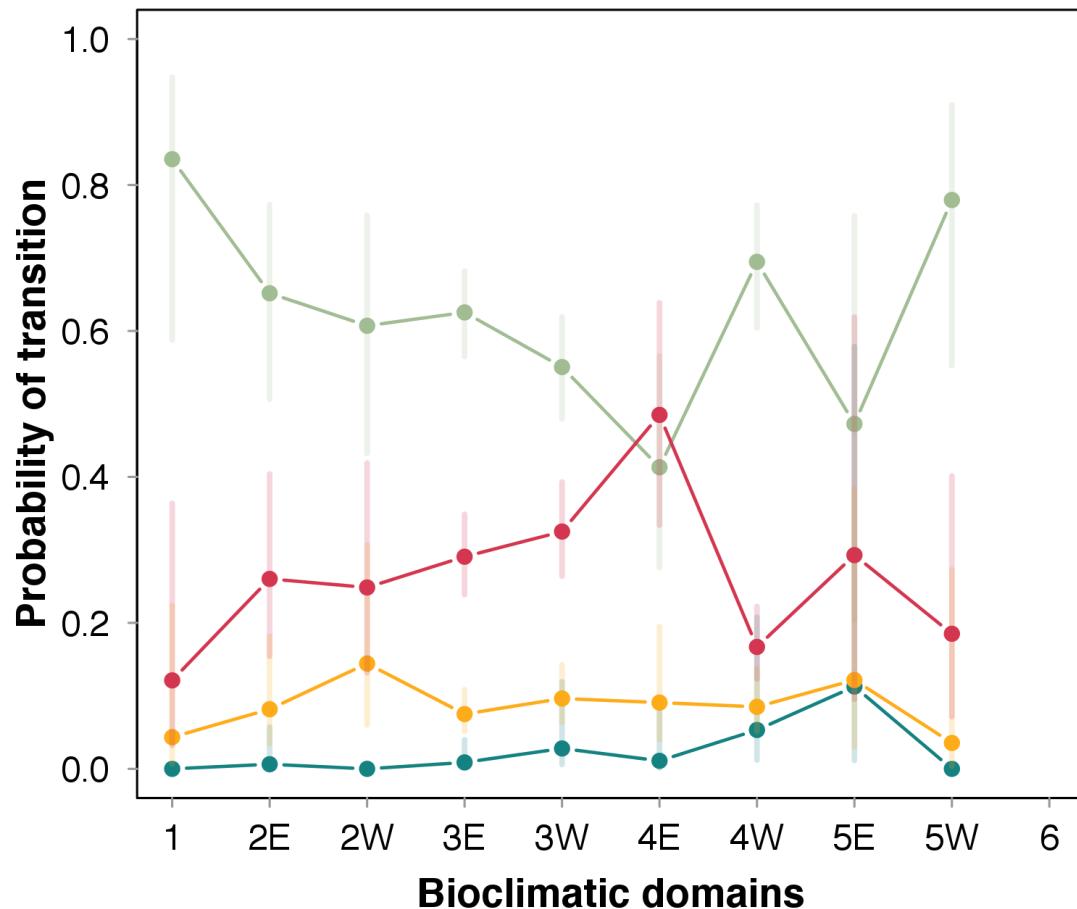


Temperature change

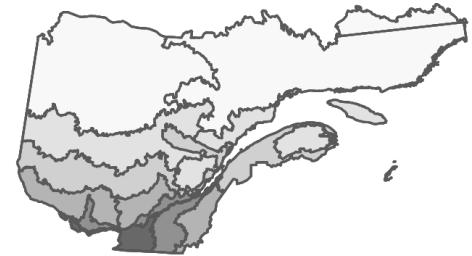


Precipitation change

# Influence du voisinage

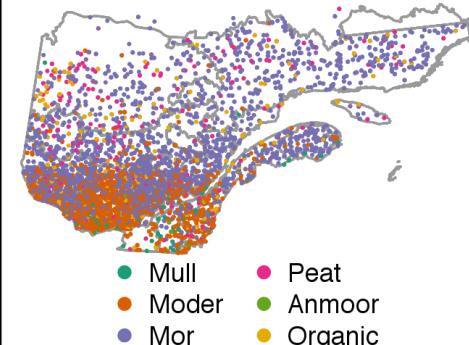
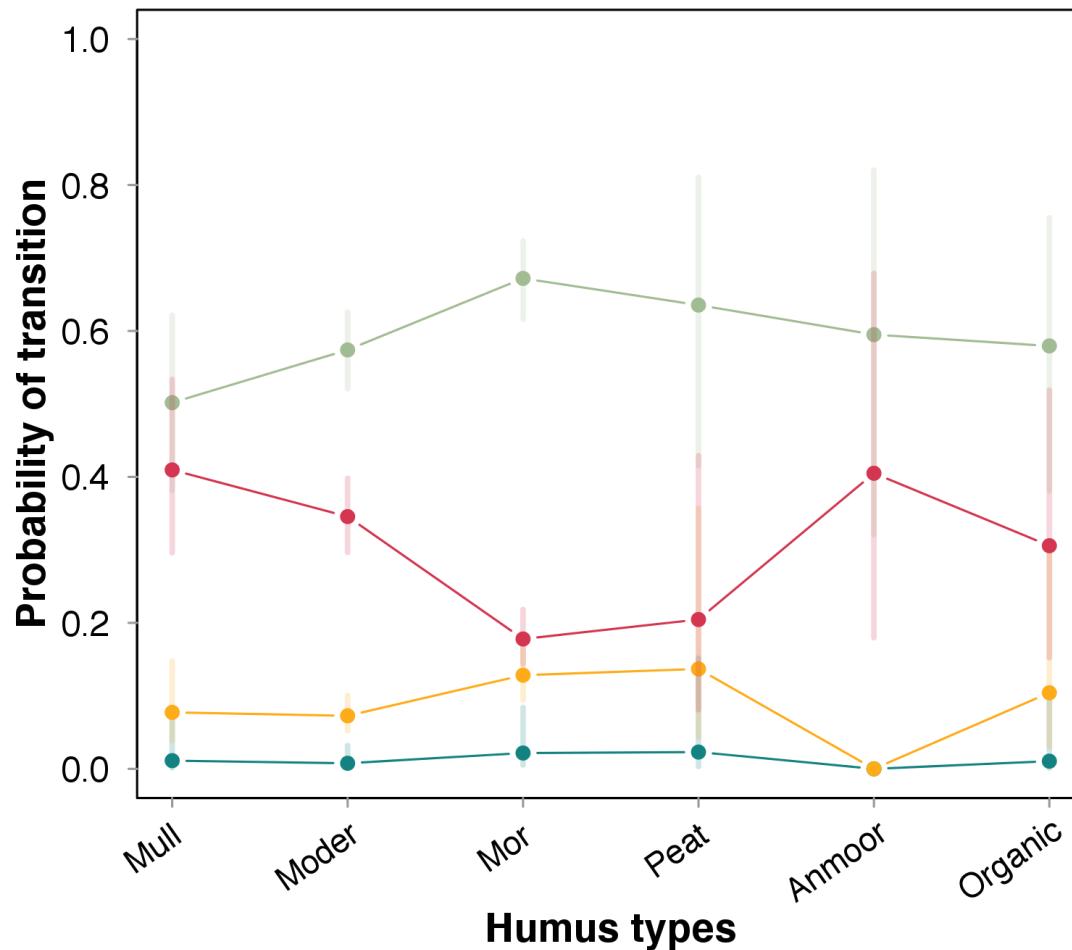


- 1 Sugar maple-bitternut hickory    4 Balsam fir-yellow birch  
2 Sugar maple-basswood            5 Balsam fir-white birch  
3 Sugar maple-yellow birch      6 Spruce-moss



Mixed  
Temperate  
Pioneer  
Boreal

# Influence du sol



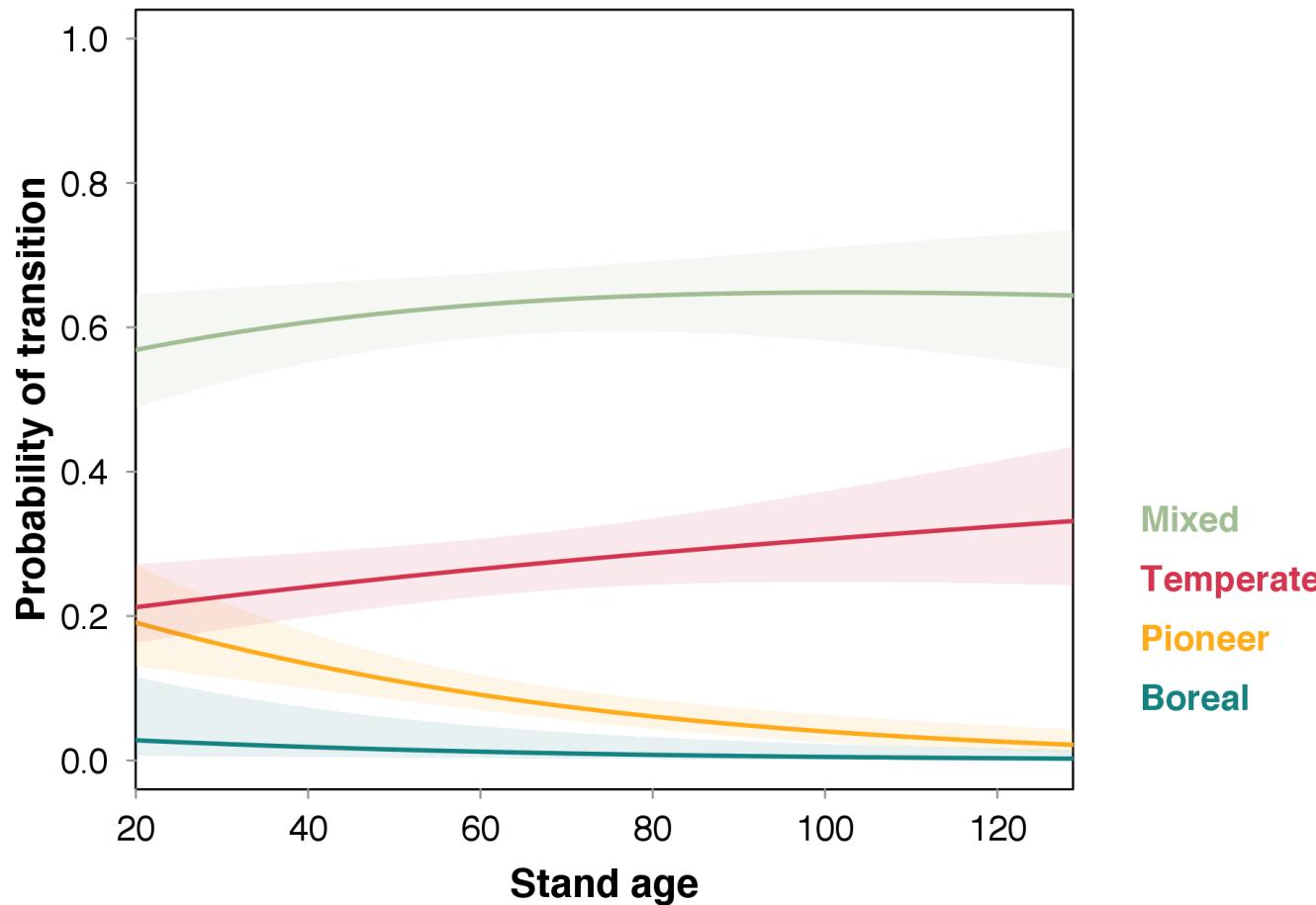
Mixed

Temperate

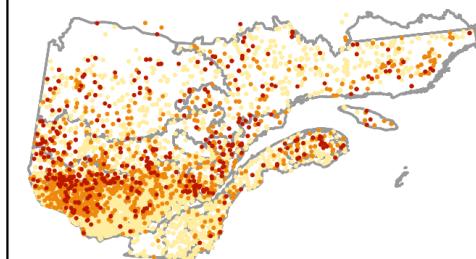
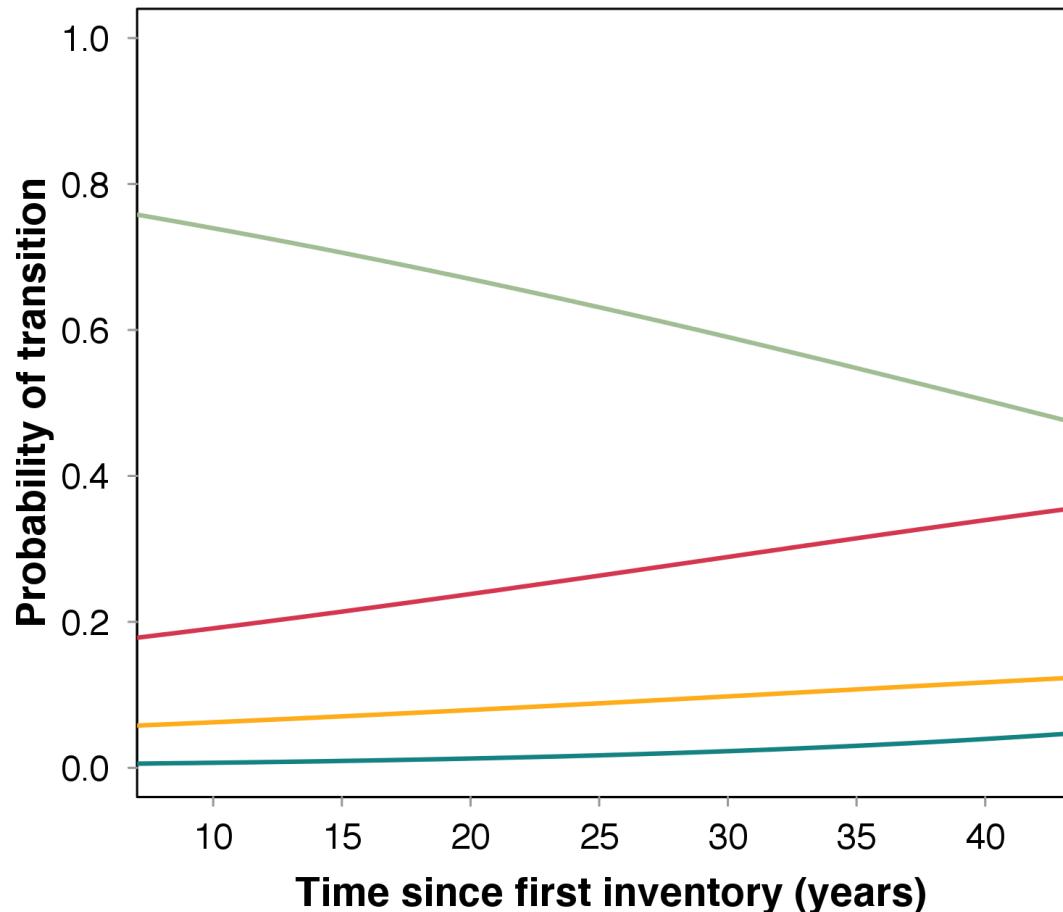
Pioneer

Boreal

# Influence de l'âge du peuplement



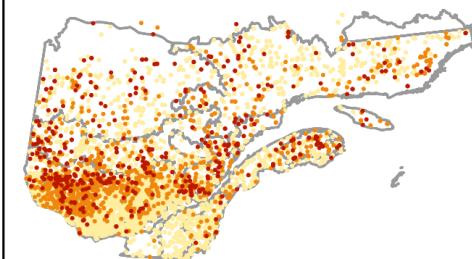
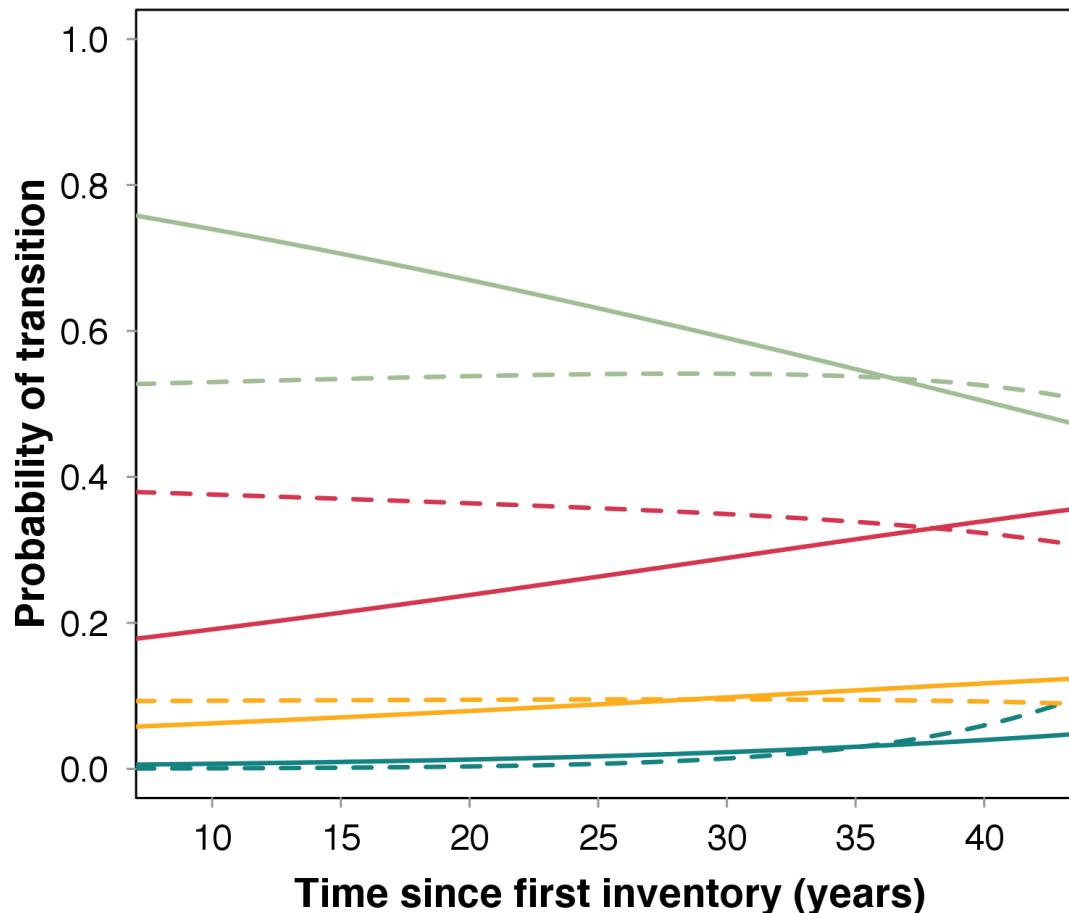
# Influence des perturbations naturelles



Mixed  
Temperate  
Pioneer  
Boreal

- No disturbances
- Moderate disturbances
- - - Major disturbances

# Influence des perturbations naturelles

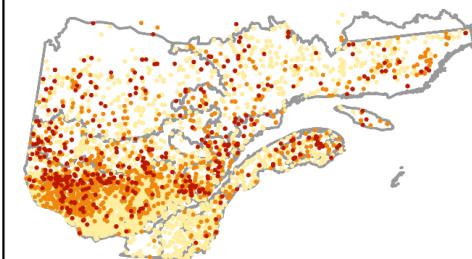
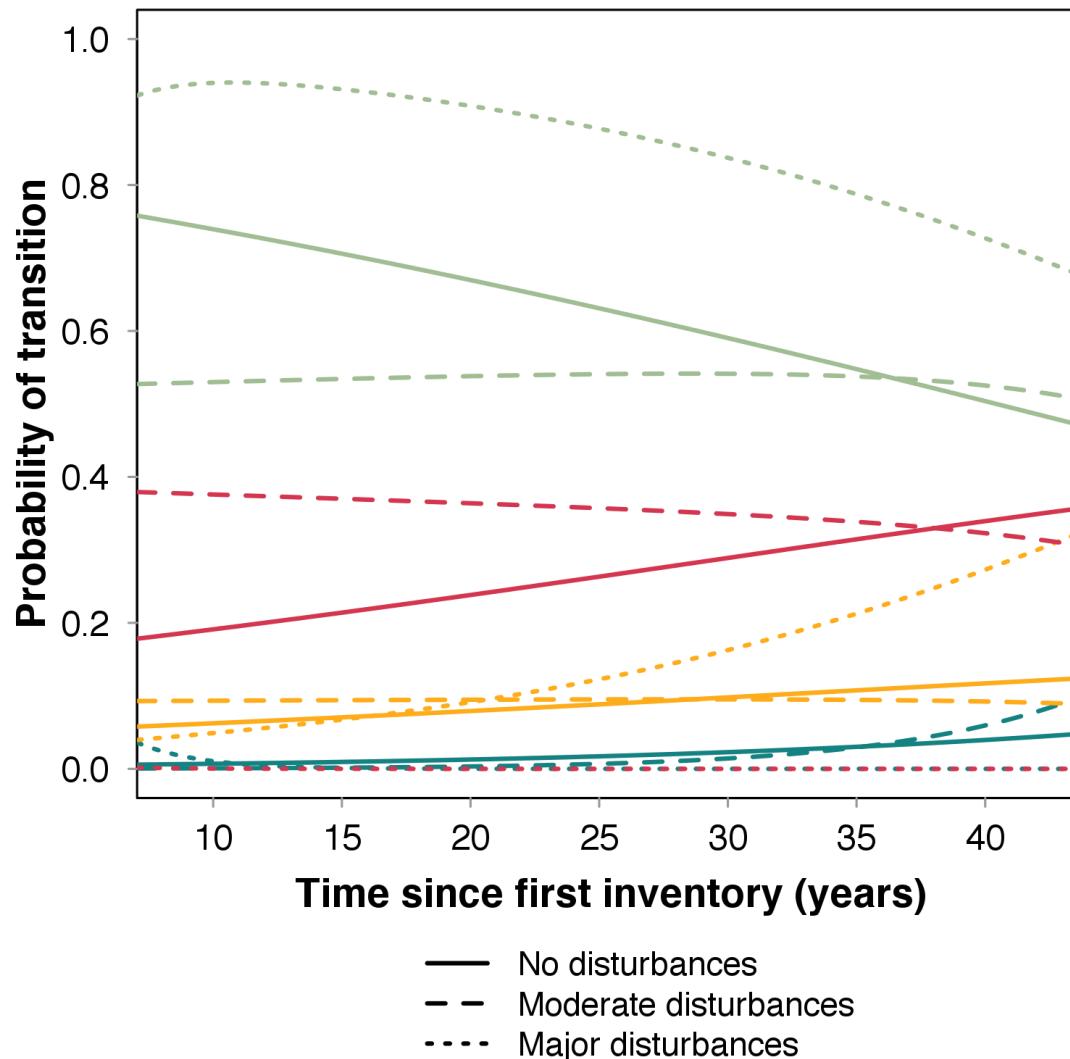


No disturbances  
Moderate disturbances  
Major disturbances

Mixed  
Temperate  
Pioneer  
Boreal

- No disturbances
- Moderate disturbances
- - - Major disturbances

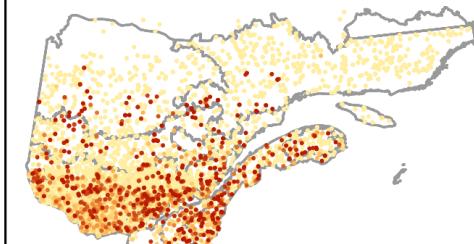
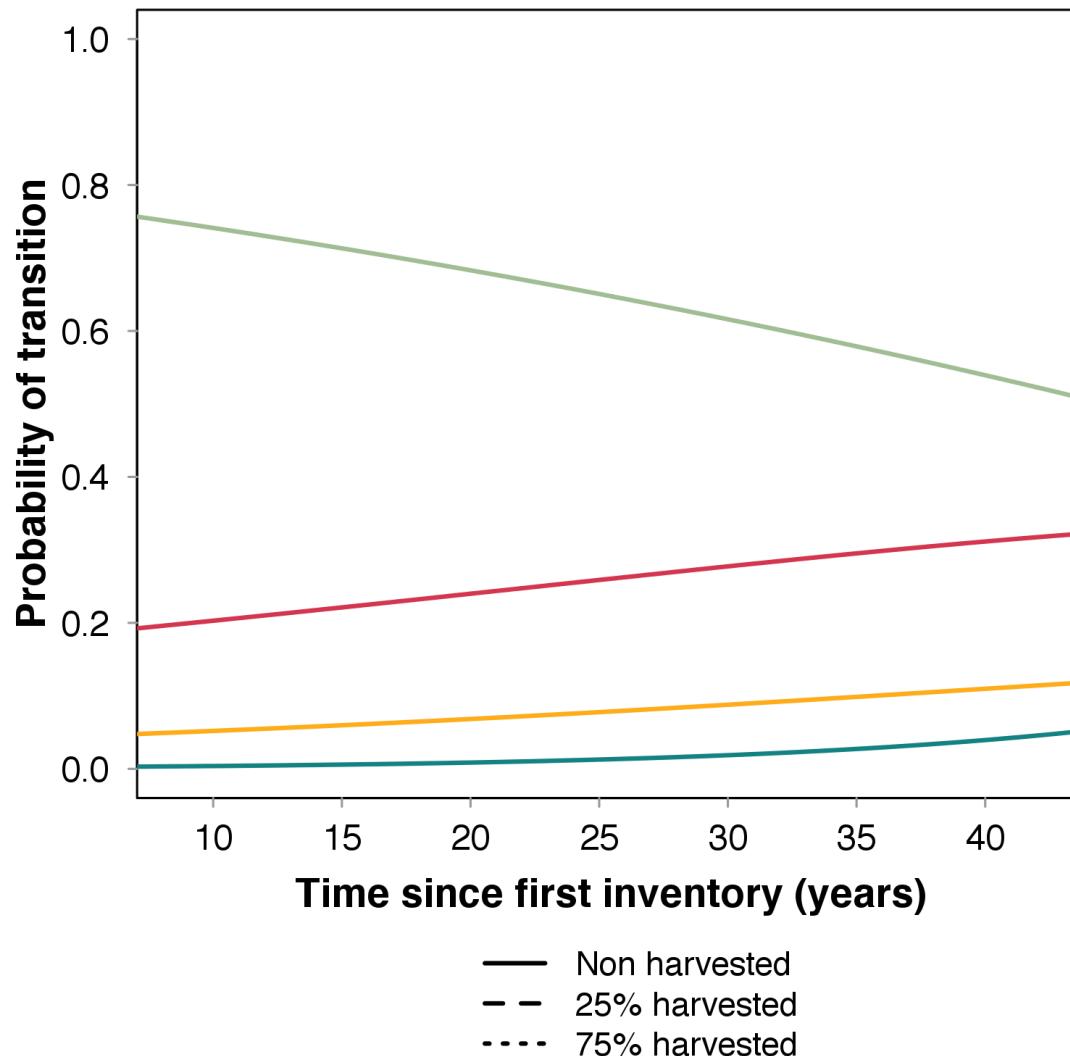
# Influence des perturbations naturelles



No disturbances  
Moderate disturbances  
Major disturbances

Mixed  
Temperate  
Pioneer  
Boreal

# Influence de la coupe forestière



Harvest intensity

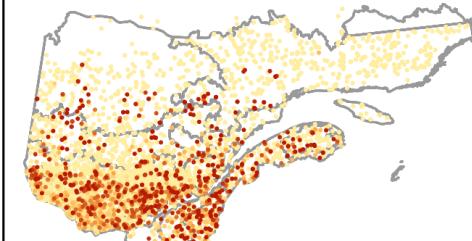
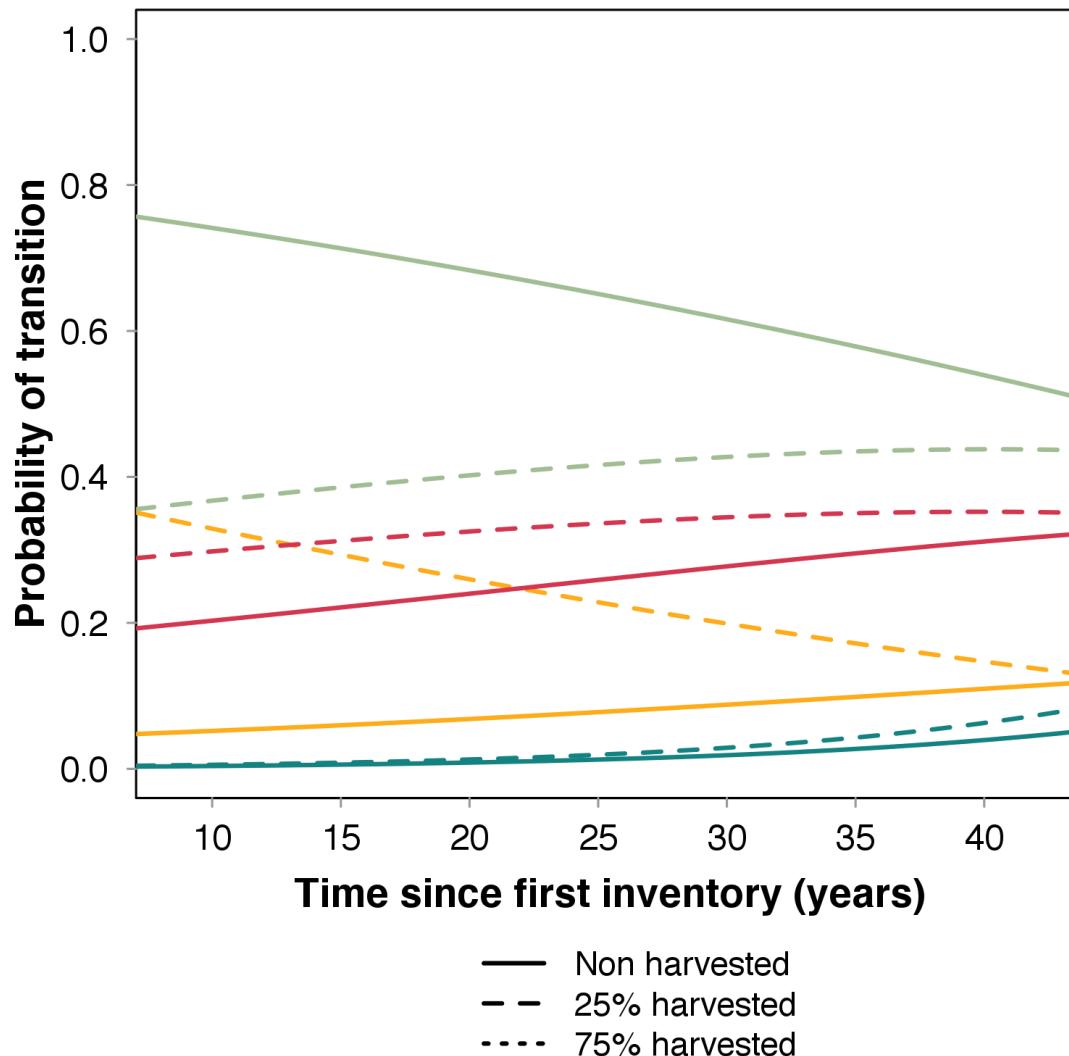
Mixed

Temperate

Pioneer

Boreal

# Influence de la coupe forestière



Harvest intensity

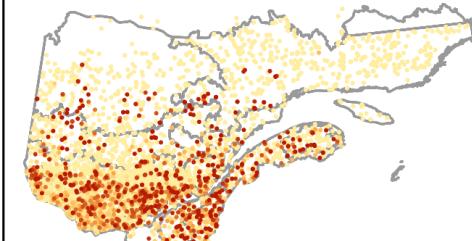
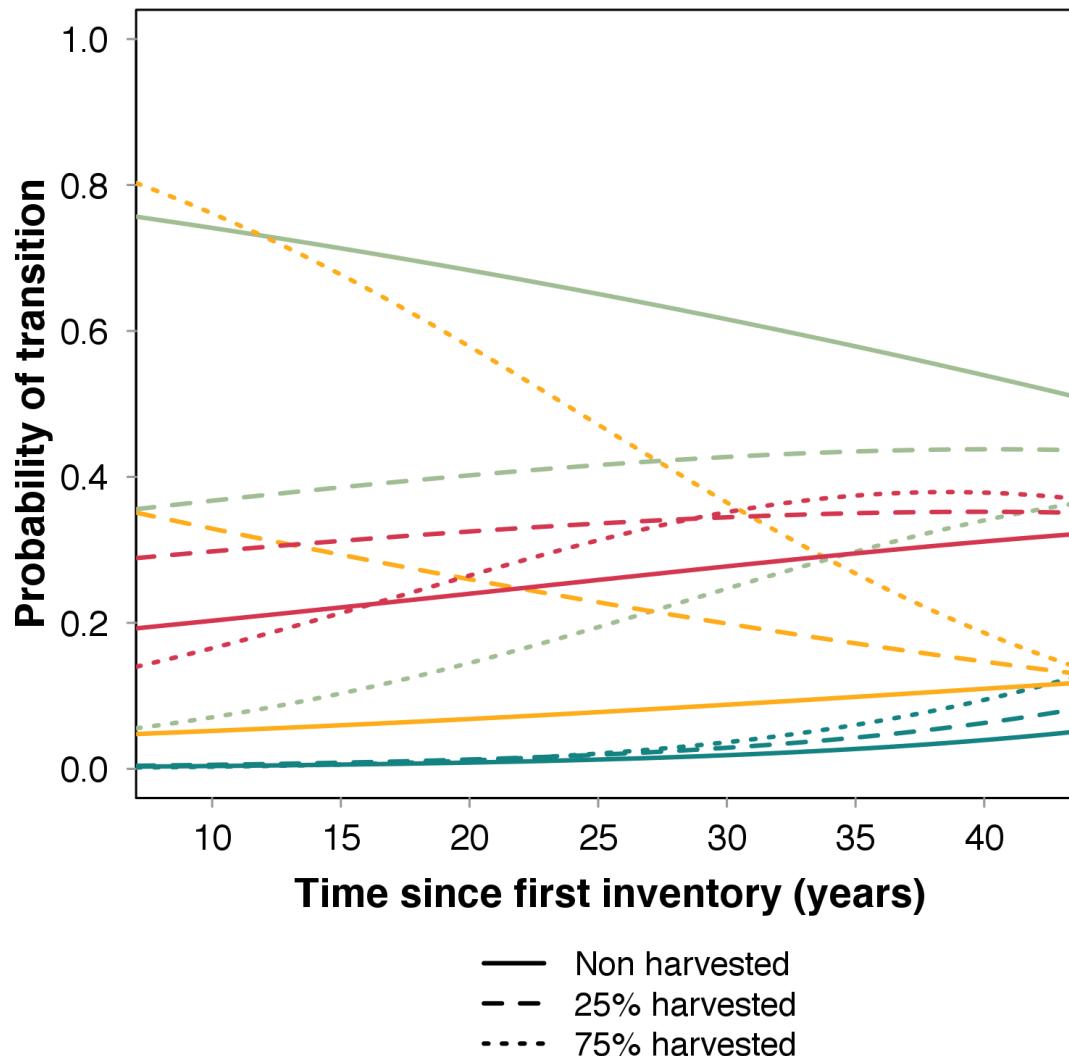
Mixed

Temperate

Pioneer

Boreal

# Influence de la coupe forestière



Harvest intensity

Mixed

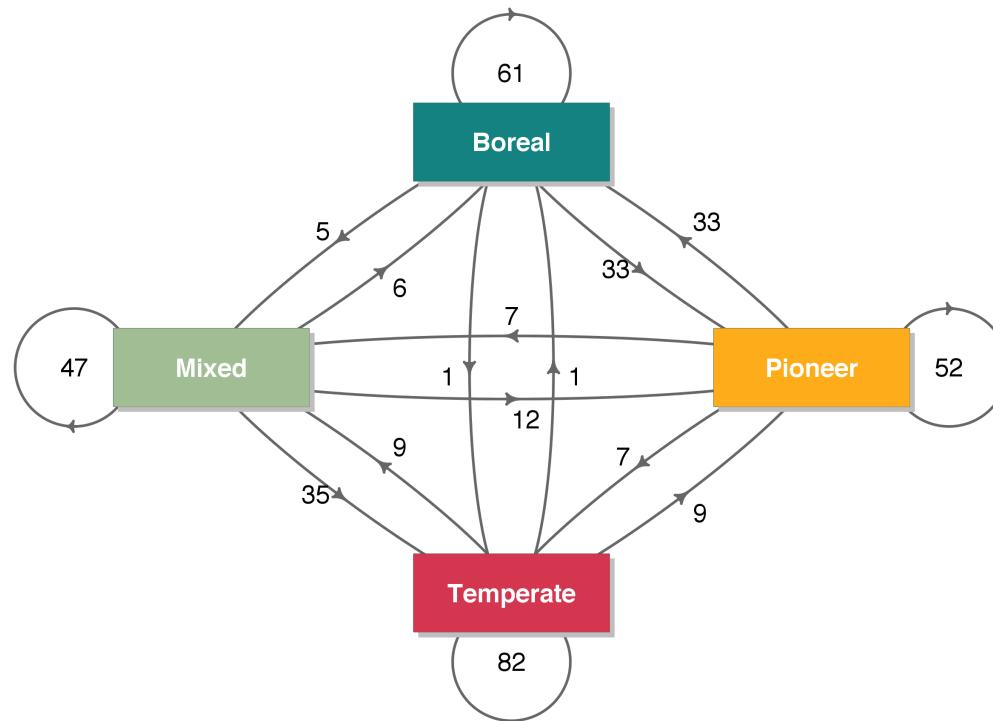
Temperate

Pioneer

Boreal

# Conclusions

① Quelles ont été les transitions d'état dans les forêts au cours des dernières décennies?



# Conclusions

② Quels facteurs environnementaux déclenchent ces transitions de communautés?

## Contrainte à la migration

 Conditions édaphiques

 Précipitations

 Compétition par les espèces boréales

## Favorable à la migration

 Vieillissement du peuplement

 Réchauffement

 Perturbations naturelles et anthropiques à court terme... mais à long terme?

# Conclusions

③ Est-ce que les perturbations peuvent accélérer certaines transitions?

