Climate Change Impacts on Eastern Canada’s Forests: Impacts on Forest Landscapes and Biodiversity

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Temperatures in Canada are rising twice as fast as the rest of the globe.
Let’s look in the future…

- **RCP**: Representative Concentration Pathways (W.m\(^{-2}\))

### Canada (land-based)

![Graphs showing annual mean daily temperature and total precipitation for Canada, projected from 1950 to 2100.](image)

**Source**: Price et al.
Projected environmental changes of unprecedented speed and amplitude pose a substantial threat to boreal forest health.
Productivity of boreal species is and will decline

Trends in forest growth from 1950 to 2002
(Assessed from NFI tree-ring data)

Trends in NPP from 1971 to 2100 RCP 8.5
(Assessed from model simulations coupled to NFI)

Girardin et al. 2016
Area burned will strongly increase, including in eastern Canada
Spruce budworm outbreak may last shorter

Baseline | 1965-1998

Short-term | 2011-2040

Mid-term | 2041-2070

Long-term | 2071-2100

Number of years with severe defoliation on a 30-year basis:
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- >6

By: Yan Boulanger, Barry Cooke, Sylvie Gauthier, David Price
What will be the cumulative impacts on forests landscapes?
Are current harvest practices affecting forest landscape resilience under climate change?
Assessing impacts on forest landscapes needs a holistic approach
LANDIS-II: a forest landscape model

LANDIS: Forest succession and disturbance model
Quebec’s forests: a very diversified landscape

- From northern hardwoods to feather-moss spruce stands
- Very diversified disturbance regime
- Ecosystem-based forest management (EBFM) implemented
- Degraded forest landscapes in the southern part
Overall impacts much higher in boreal than within mixedwood or northern hardwood
Important changes in forest landscapes but spatially heterogeneous
Northward migration of temperate species: not so much... Increased fire have a big toll on boreal, even local extirpation!

A) Red maple

B) Black spruce
Huge growth constraints on boreal species
Changes in maxAGB (2080 vs 2000)
1) Thermophilous species increase in mixed- and Northern hardwood;
2) Harvest is promoting thermophilous;
3) Pioneer species much more common in boreal.

A) Thermophilous species (vs boreal)

B) Pioneer species (vs mid-/late-successional)
1) Boreal forest mostly affected by changes in abundance
2) Southern regions also affected by changes in species composition (to a certain extent)

Big climate-induced drop in boreal species biomass under RCP 8.5, but also thermophilous!
Under strong warming, even thermophilous species are negatively affected

- Northward migration into boreal realm of these species might be compromised
In a nutshell...

- Boreal forest seems less resilient than Mixedwood and Northern Hardwood:
  - Natural disturbances outside range of natural variability;
  - No climate-adapted species to compensate boreal losses
- Changes in species composition occur mostly in regions where boreal and temperate species co-occur. Temperate wins (to a certain extent)!
- But under RCP 8.5, even thermophilous might be negatively affected: drop in resiliency
In a nutshell...

- **Biomass decline**: large impacts on timber supply, carbone storage, ...

- **Change species composition**: impacts on biodiversity, wood products...
- **Harvesting hastening composition changes**
- **Is management the key?**
Historical harvesting strongly changed forest landscapes in southern Quebec. Can EBFM bring back these landscapes under CC?

Boulanger et al. 2019
EBFM is the “lesser of all evils”
Climate- and harvest-induced changes in forest landscapes will strongly impact biodiversity habitats, but how?
Forest change and biodiversity

- Climate change should affect (contract?) species range
Climate change impacts on biodiversity mostly assessed using species distribution models. These do not explicitly account for changes in forest landscapes.

Breeding season

Non-breeding season
Forest change and biodiversity

- Climate change should affect (contract?) species range
- Both harvest and climate change will affect forest composition but also its structure (e.g., age classes)
- Impact on biodiversity will be highly dependant on communities, trophic levels
- Regions where changes will be minimal (e.g., "refugia") must be identified
- Important considerations for forest management and conservation strategies
Bird-habitat associations

4) Develop BRT models for each species

2) LANDIS-II model

3) Tree species biomass = habitat cover

https://carnrfaculty.missouri.edu/gislab/landis/

1) PICUS model

http://picus.boku.ac.at/doku.php

4) Develop BRT models for each species

5) Projected population density by simulation scenario
Ex.: Swainson's Thrush, RCP 8.5, With harvest

Year: 2020
Generalists and species associated with deciduous stands are favored by climate change (RCP 8.5)
Climate sensitive species mostly associated with mixed and coniferous forests.
The special case of species at risk

- The number of species at risk (SAR) in Canada is steadily increasing.
- Habitat degradation or loss is a significant threat to many SAR.
- However, the role of natural and anthropogenic disturbances on the recovery potential of SAR is often not well understood.
  - This is especially true in the context of climate change
- In addition, climate change is often perceived as a threat to SAR but is rarely assessed.
  - Evaluation on a 10-year horizon
Woodland Caribou habitat

- Designed as threatened in 2000
- National recovery strategy
- Strongly impacted by human-induced disturbances
- Southern fringe: very fragmented and disturbed
- Local extirpations in the south, northward retraction
- Climate change will affect habitat quality, behaviour and demography
Climate change and harvest greatly affect suitable forest covers but differently spatially

- **Assinica (lots of fires)**
- **Manicouagan (less fires)**

### Diagram Details

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**Legend**

- **Regeneration**
- **Harvested stands**
- **Natural disturbance**
- **Open coniferous stands**
- **Mature conifer and mixed stands**
- **Old conifer and mixed stands**
Caribou Habitat suitability model
RCP 8.5, Harvest

Year: 2020
Habitat suitability index drops with cumulative harvest and climate change
Harvest much more important than climate change, except under RCP 8.5 after 2100

Suggests that ongoing climate change had very little impacts on changes in the historical range...
Another example: the Bicknell’s thrush

- SAR in Canada
- Summer range restrained to NE North America
- Very specific habitat
  - High altitude
  - Young balsam fir stands (10,000 – 50,000 stems/ha)
Strong impacts of climate change in lower altitudes on conifers: ecotone migration

Boreal shield region

Proportion of coniferous tree species biomass

Altitude category

Baseline

RCP 2.6

RCP 4.5

RCP 8.5

Cadieux et al. 2019
Clearcutting without thinning helps keep higher proportion of dense conifer stands, under high forcing, but mostly at higher elevations.
In a nutshell...

- Large impact on biodiversity projected
- Impacts very different between communities
- Harvest has a very strong impacts, much more than CC, on some SAR
- Forest management can help conservation strategies
- Some regions may act as refugia but they are rather small
- Much more work is needed to better understand CC impacts on biodiversity, notably on conservation strategies
Thanks!
Résultats Zone de conservation

Proportion de l’habitat convenable pour la Grive de Bicknell dans les zones de conservations en 2100 sous RCP8.5. (région du bouclier boréal)

Scénarios d’aménagement
- Coupe totale
- Coupe partielle
- Pas de coupe

Zones de conservation

Proportion d'habitat potentiel (%)

Année

Graphe de la proportion d'habitat convenable pour la Grive de Bicknell dans les zones de conservations en 2100 sous RCP8.5. pour les scénarios d'aménagement (coupes totales, coupes partielles, pas de coupe).
Dissimilarities with baseline climate

2100

2150

RCP 4.5

RCP 8.5

- High change w/ & w-o harvest
- High change w/o harvest
- High change w/ harvest
- Low change w/ & w-o harvest
- Low change w/o harvest
- Low change w/ harvest

Natural Resources
Canada

Ressources naturelles
Canada
Scénarios projetés
- Seulement RCPs (pas de scénario climatique de base)
- Tous les régimes de feux et d’exploitation forestières

Conditions initiales (2000)

Projections 2100
Importance des impacts

Moyennes des conditions

Habitats de haute qualité

Changements dans la croissance

Coupes forestières

Augmentation des feux

*Values < 0.001 not show
Are models agreeing?
Are models agreeing?

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Are models agreeing?  
Ex.: RCP 8.5 2071-2100

A) Balsam fir  
B) Sugar maple
Menaces

- Pertes d’habitat en aires de nidification et d’hivernage
  Ex.: Parcs éoliens, pré-comm.
- Les changements climatiques pourraient avoir un impact très important sur son habitat (Rodenhouse et al. 2008) via la diminution des sapinières (feux + $T^\circ$)
En résumé

- Les impacts des changements climatiques affecteront grandement les peuplements de conifères et la structure d’âge
- Les impacts seront surtout importants en lien avec une augmentation des feux (centre du Québec)
- Impacts plus importants sous le scenario de changements climatiques le plus sévère (RCP 8.5)
- L’exploitation forestière module fortement les impacts des changements climatiques sur la forêt et conséquemment sur les habitats
Implications pour conservation

- Les impacts des changements climatiques sur les habitats essentiels varieront d’une espèce à l’autre;
- L’aménagement forestier aura un impact non-négligeable sur le potentiel des stratégies de rétablissement dans un contexte de changements climatiques
  - Opportunités importantes pour adapter l’aménagement forestier et tenter de limiter les impacts des changements climatiques
- Étape suivante : Prendre le tout en considération pour les plans de rétablissement