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Simulating Spatio-Temporal Dynamics of Boreal Bird Habitats Under Natural and Anthropogenic Disturbances in a Climate-Change Context

Junior A. Tremblay, Yan Boulanger, Dominic Cyr, David Price,
Diana Stralberg, Anthony Taylor

Natural Resources Canada
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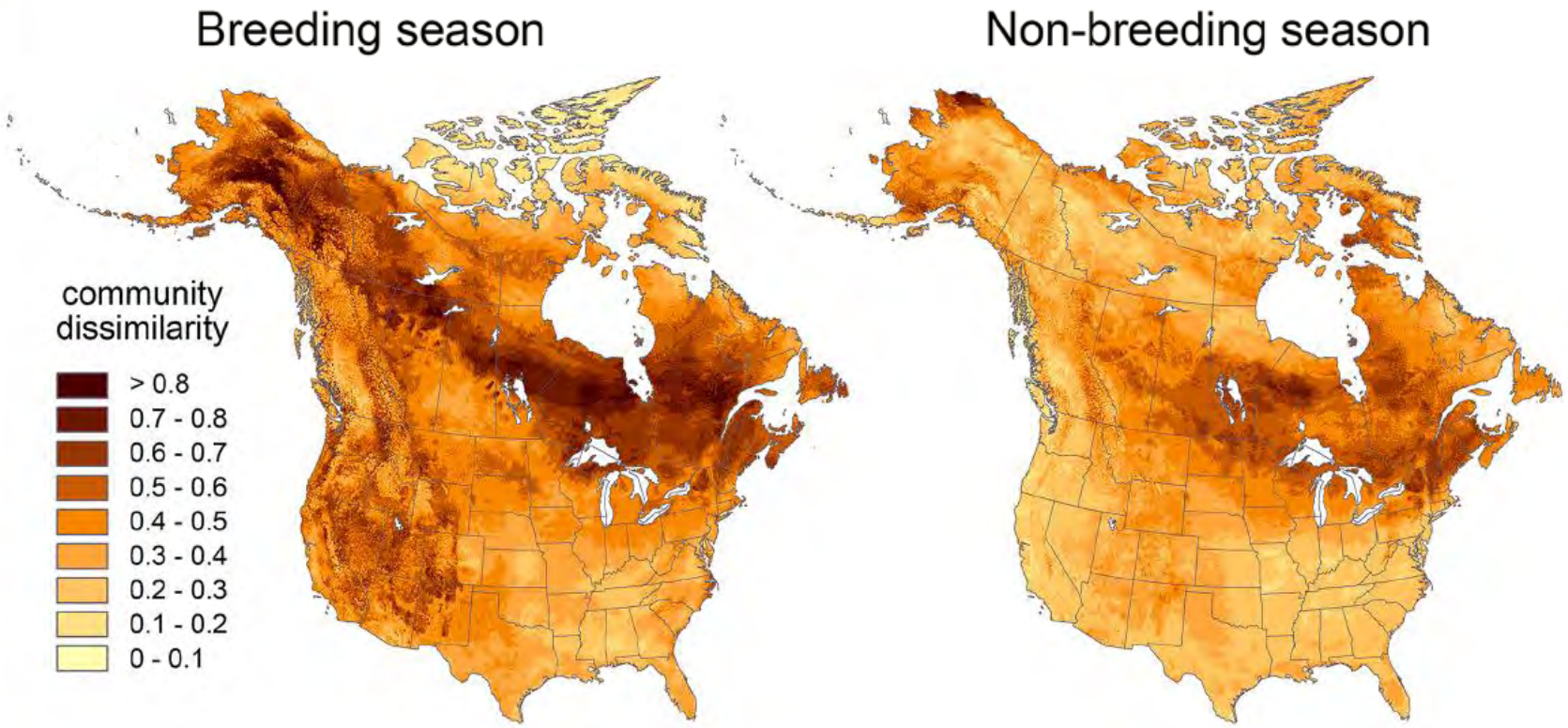
Canada

10e colloque annuel du CEF
3 Mai 2016

UNIVERSITY OF ALBERTA

Introduction
Climate change and birds



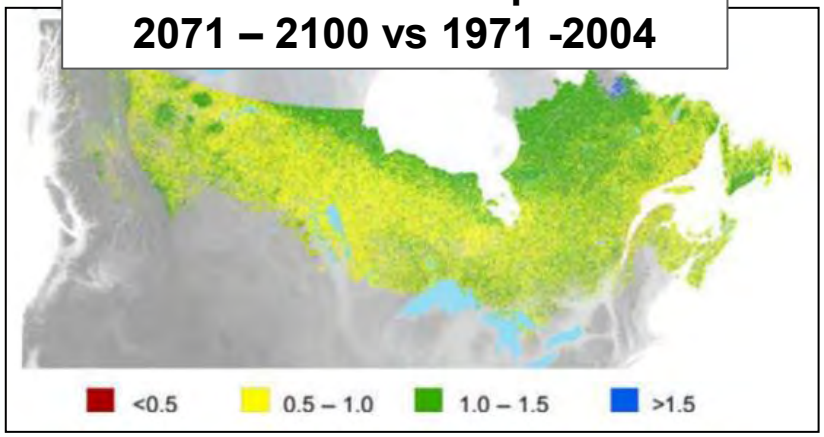
Langham et al. 2015

Introduction

Climate-induced changes in forest landscapes

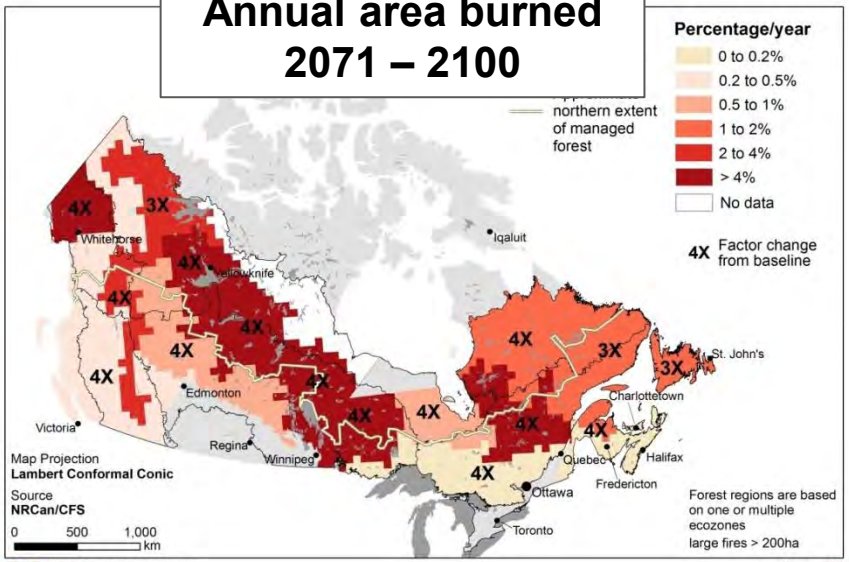
- Changes in growth rates, mortality, regeneration
- Changes in disturbance regime (e.g. fire, pest outbreaks)

NPP ratio black spruce
2071 – 2100 vs 1971 -2004



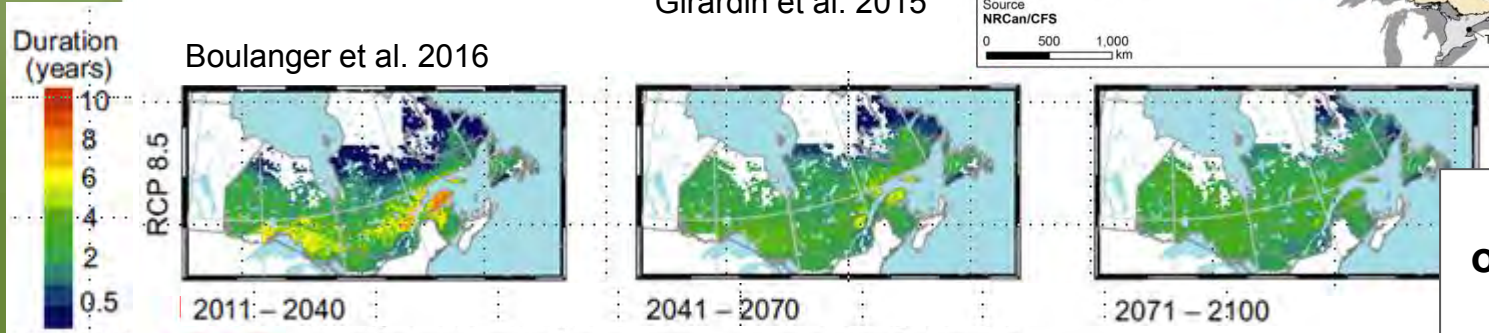
Girardin et al. 2015

Annual area burned
2071 – 2100



Boulanger et al. 2014

Boulanger et al. 2016

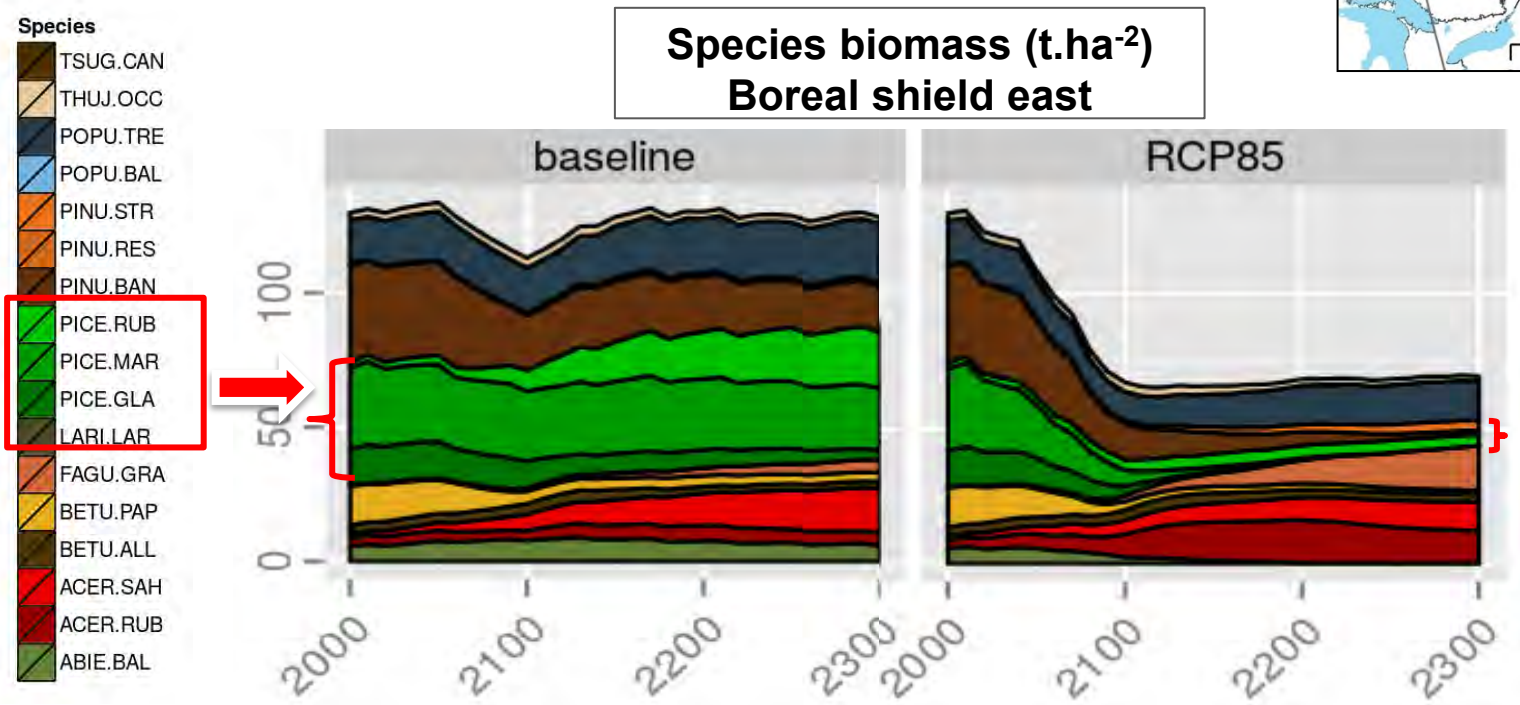


Predicted outbreak duration
2071 – 2100

Introduction

Climate-induced changes in forest landscapes

- Example: boreal tree species are at risk



Boulanger et al. in press

Introduction

Climate change effects on boreal birds

- Most of studies projecting future bird habitats rely on climate projections. This approach does not take into account the projected realized migration of the habitat (e.g., forest cover)

- Forest landscape models (FLM) simulate stand- (e.g., succession, growth) and landscape-scale processes (e.g., seed dispersal, natural and anthropogenic disturbances) allowing for more realistic projections of bird habitats.

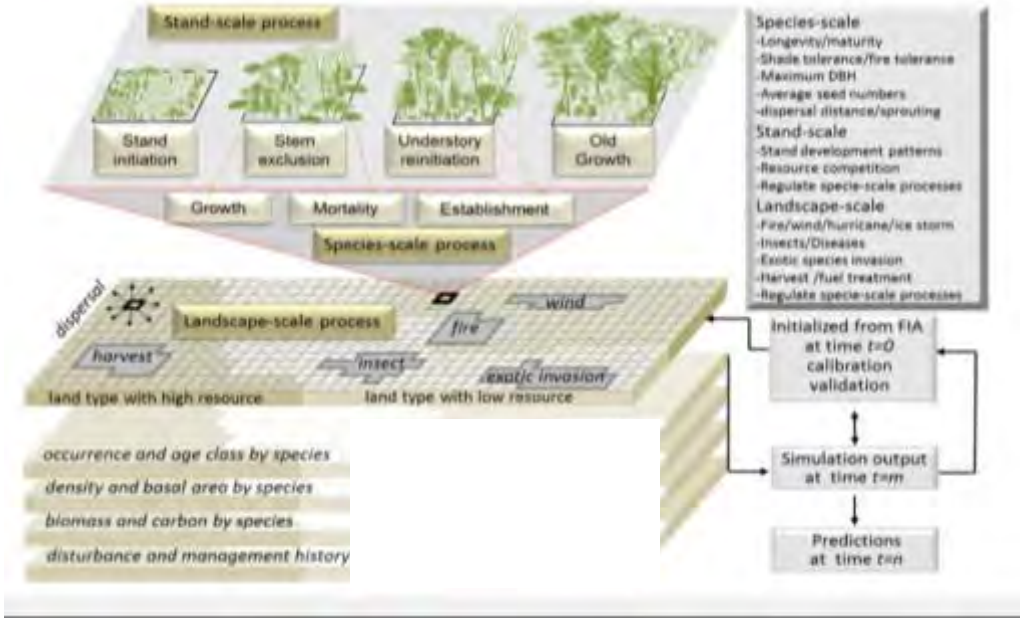
Study objectives

- Estimate impacts of climate change on abundance of boreal birds in a dynamic landscape under anthropogenic (forest management) and natural disturbances using a FLM

Two case studies :

1. Impact of climate change on productivity of a focal species in boreal forest
   - Black-backed Woodpecker (BBWO)
2. Impact of climate change on critical habitat of a boreal bird
   - Bicknell's Thrush (BITH)

Methods
The model (Landis-II)



Adapted from Wang et al. 2014

- Simulate stand- (growth, forest succession) and landscape-scale processes (dispersal, disturbances) at a 5y timestep.
- 5 replicates per scenarios

- Baseline (1901-2000 climate) and 3 RCP scenarios run under CanESM2
- Climate-sensitive processes: fire, growth, regeneration
- Disturbances: harvesting, wildfire and insect outbreaks (SBW)

AR5 global warming increase (°C) projections

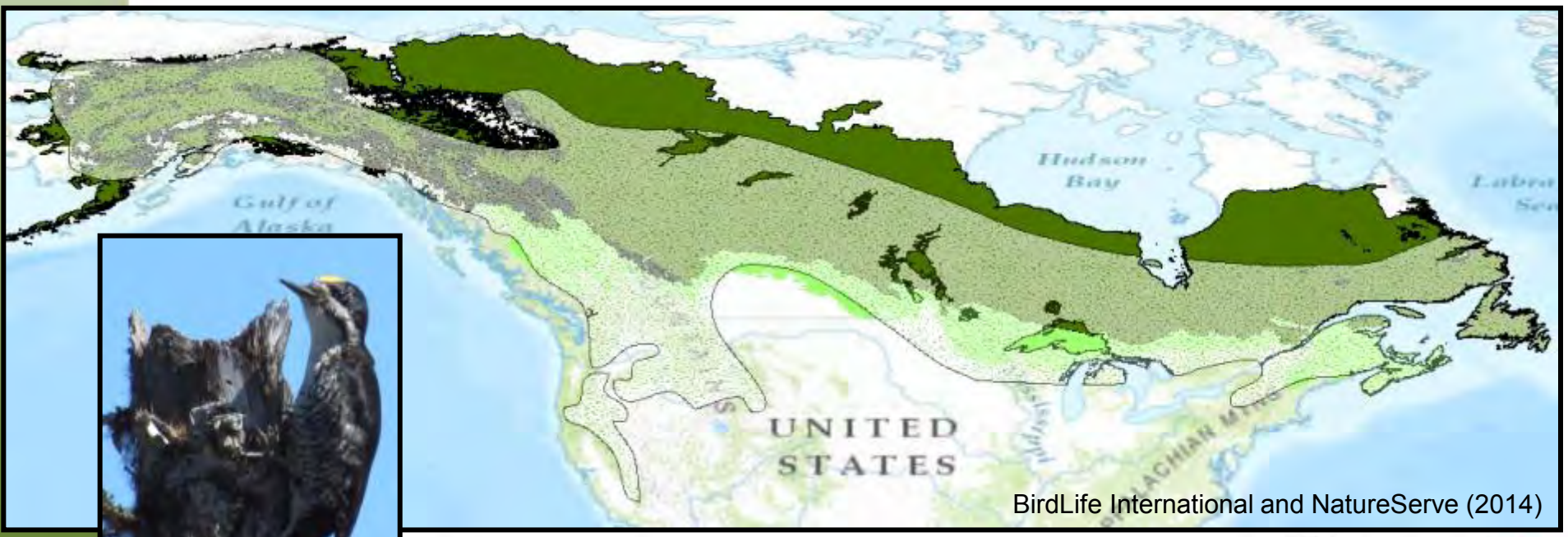
	2046-2065	2081-2100
Scenario	Mean and *likely* range	Mean and *likely* range
RCP2.6	1.0 (0.4 to 1.6)	1.0 (0.3 to 1.7)
RCP4.5	1.4 (0.9 to 2.0)	1.8 (1.1 to 2.6)
RCP8.5	2.0 (1.4 to 2.6)	3.7 (2.6 to 4.8)

Adapted from IPCC 2013

Case study 1 – Productivity of a focal species

Black-backed Woodpecker

Habitat type	Mean home range size (ha)	Mean productivity (nb fledglings)	References
Mature coniferous forest	150	1.5	Tremblay et al. 2009 Tremblay et al. 2016
Mature mixed forest	300	1.0	
Mature coniferous recently burned	100	1.12	Nappi and Drapeau 2009 Tremblay et al. 2016
Young coniferous recently burned	500	0.25	

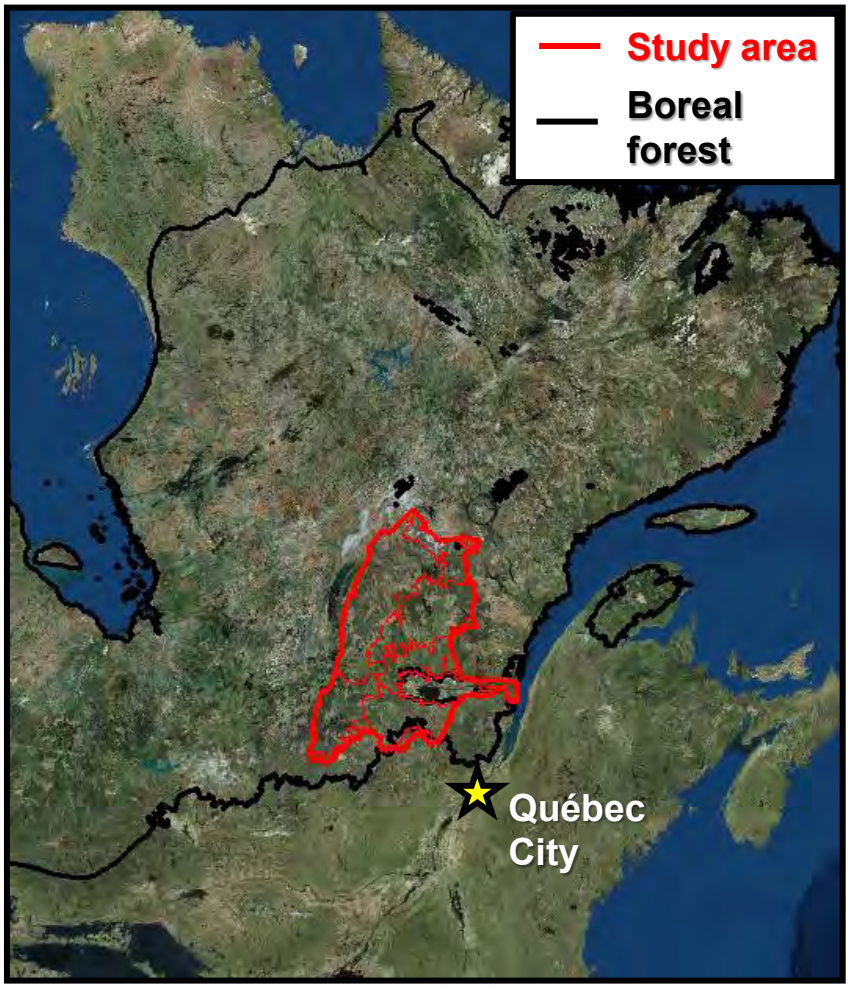


BirdLife International and NatureServe (2014)

Photo: Jérôme Rioux

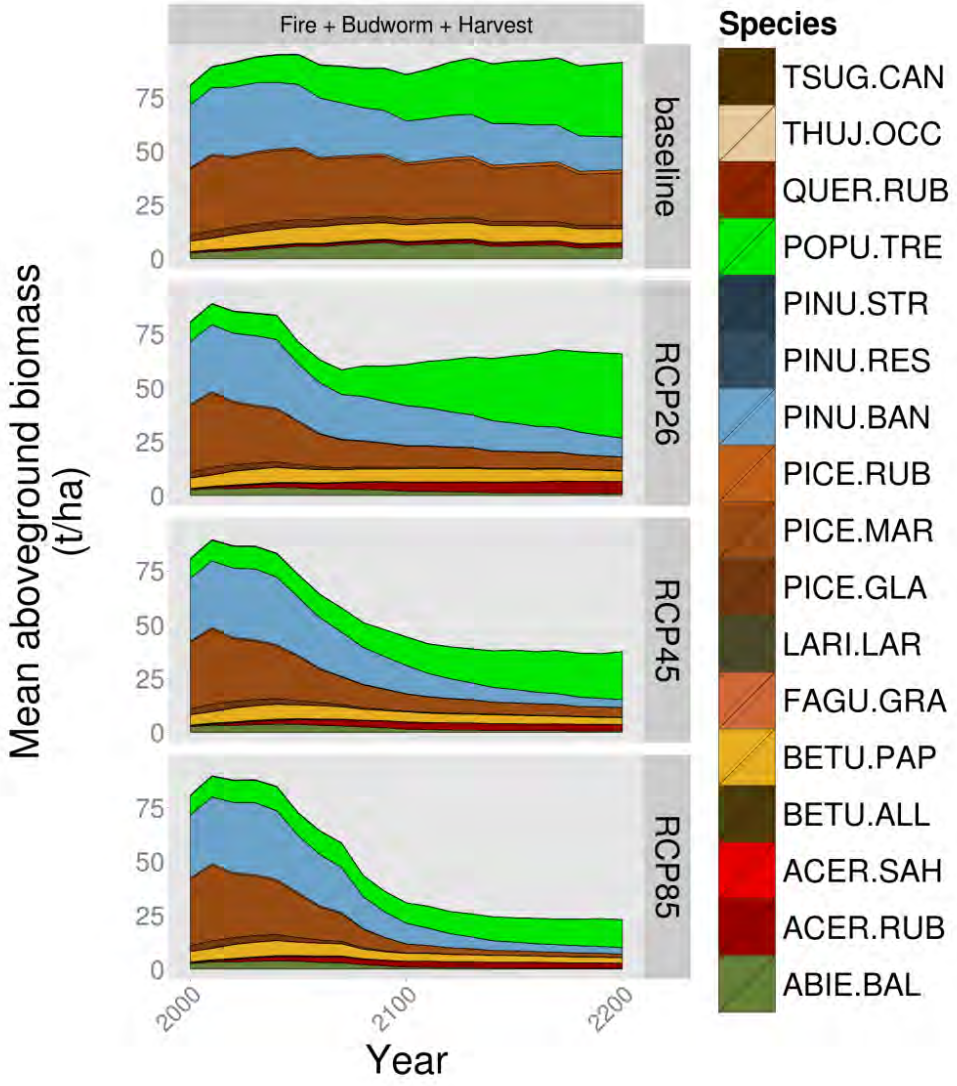
Study area

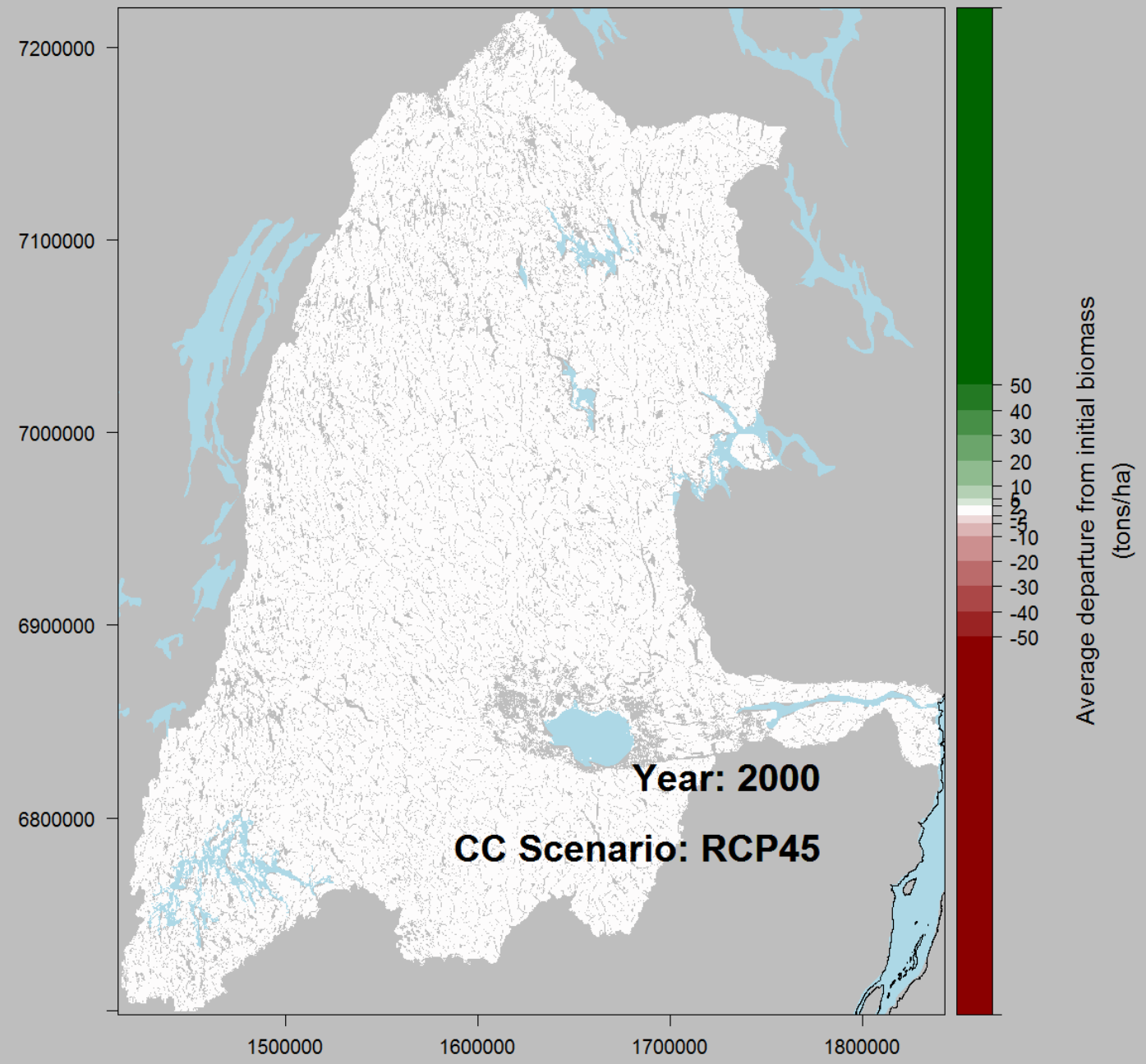
- Coniferous tree species increase in abundance with latitude
  - balsam fir
  - black spruce
  - jack pine
- Large and rather frequent stand-replacing fires
- Recurrent spruce budworm in the mixed forest portions

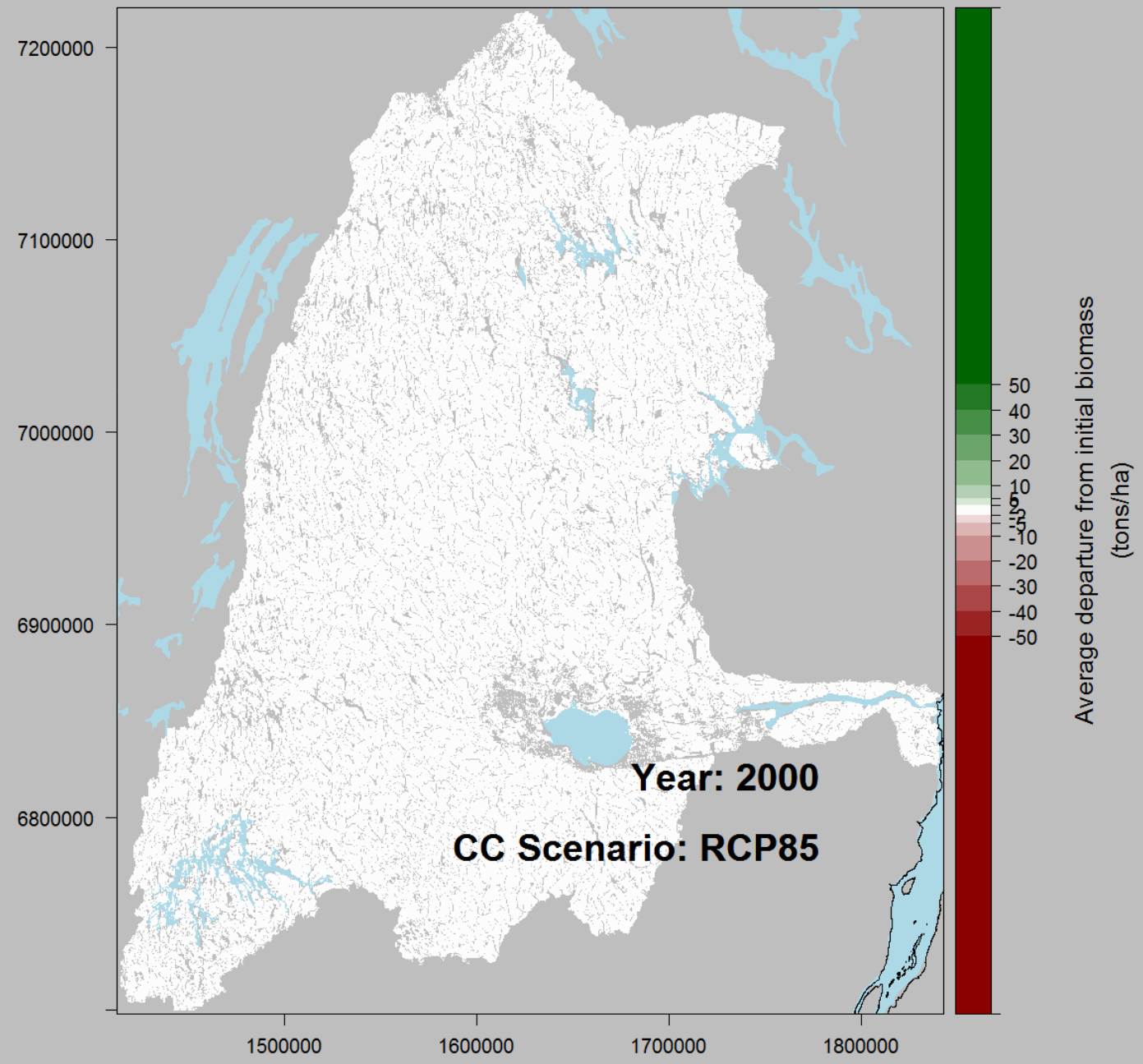


Results Evoluation of landscape composition

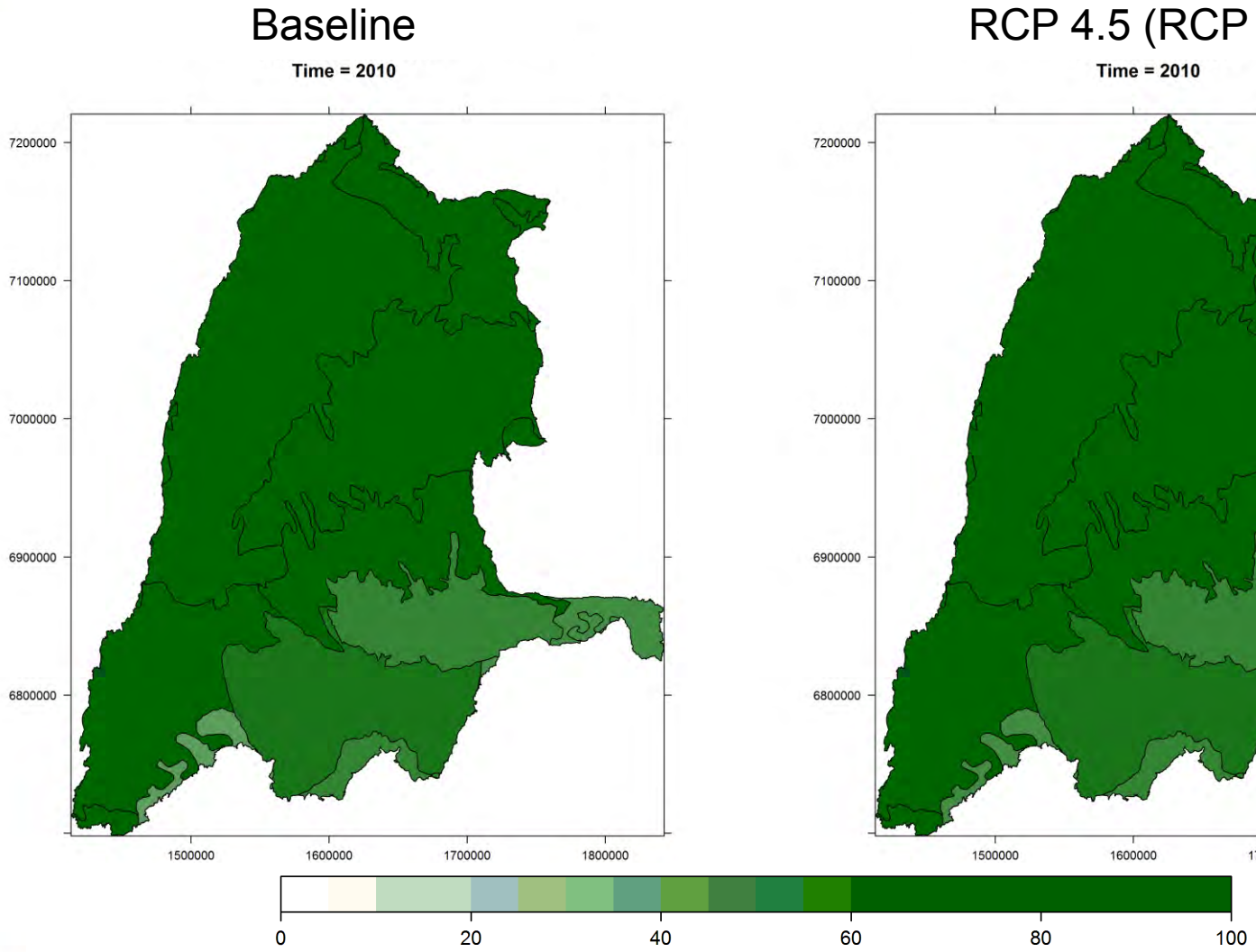
- High reduction of general biomass in RCP 4.5 and 8.5
  - Tipping point ~ 2060-2080
  - Black spruce is one of the greatest loser
- Mostly due to an increase in wildfire recurrence and a diminution in primary productivity



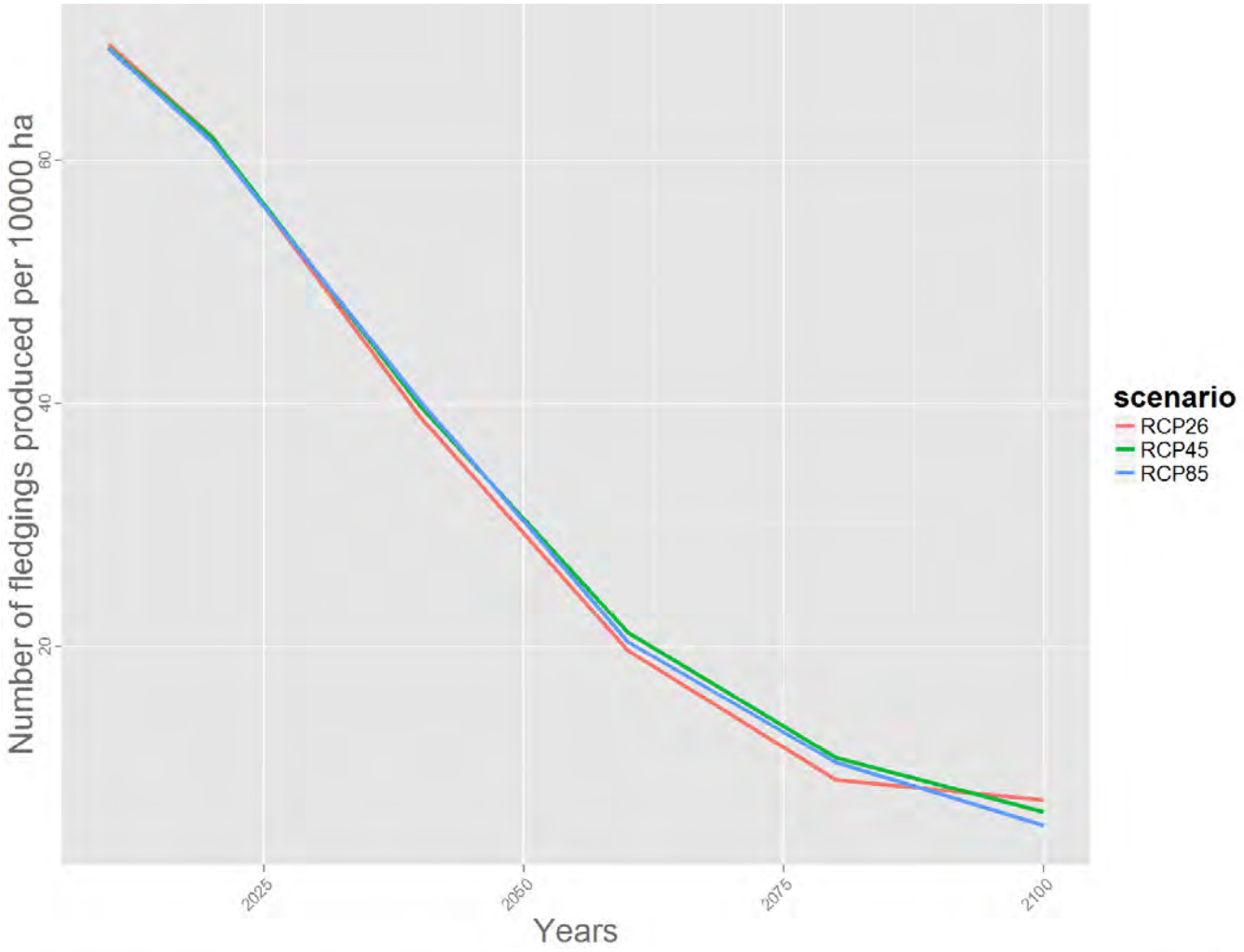

Variations in total aboveground biomass
Lac Saint-Jean - Picea mariana
7200000
7100000
7000000
6900000
6800000
1500000
1600000
1700000
1800000
50
40
30
20
10
-10
-20
-30
-40
-50
Average departure from initial biomass
(tons/ha)
Year: 2000
CC Scenario: RCP45


Variations in total aboveground biomass
Lac Saint-Jean - Picea mariana
7200000
7100000
7000000
6900000
6800000
1500000
1600000
1700000
1800000
Year: 2000
CC Scenario: RCP85
50
40
30
20
10
5
-5
-10
-20
-30
-40
-50
Average departure from initial biomass
(tons/ha)

Results Spatio-temporal trends in BBWO productivity



Results Temporal trends in BBWO productivity



Discussion

- Climate change, by triggering losses of burned and unburned mature coniferous forests, is expected to dramatically impact BBWO in eastern boreal forests.
- High post-fire salvage logging pressure could further enhance the loss of BBWO habitats (not included in our simulations)
- Northern ecodistricts may represent refugia, and expected shifts in species range need to be investigated at a larger scale.

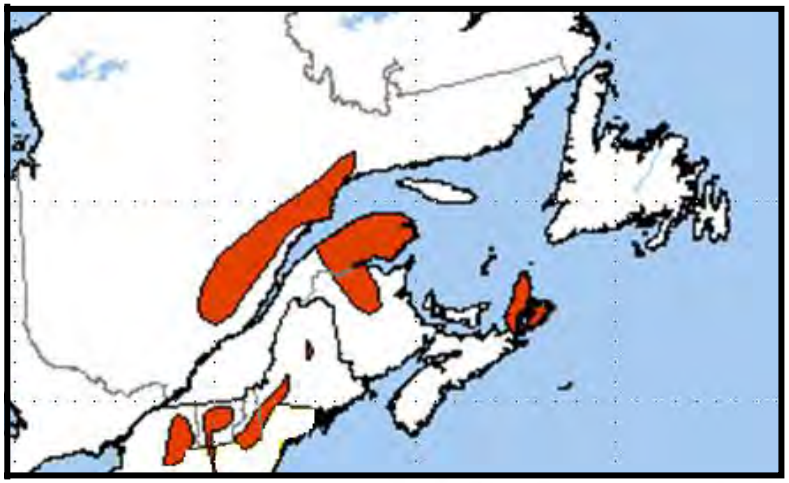
- Fine-tuning needed on harvesting prescriptions, fire regime (retroaction with younger forest stands) and spatial-explicit BBWO home range

Bicknell's Thrush

- Threatened species in Canada
- Limited breeding range in northeast North America
- Narrow habitat niche
  - High altitude young and dense balsam fir stands (10 000 – 40 000 stems/ha)

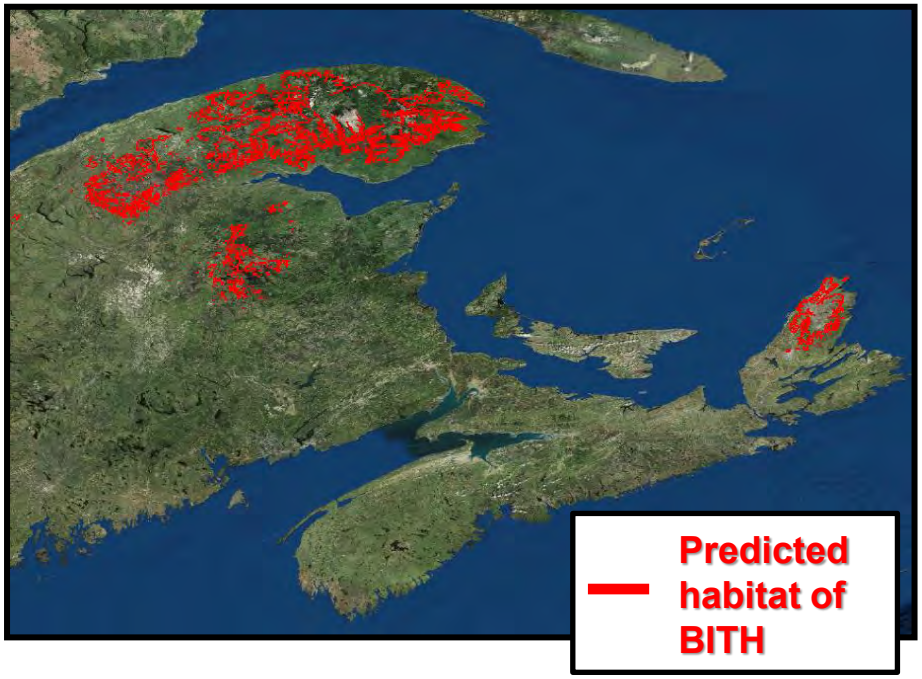
Objective

- Understanding critical habitat dynamics of the BITH under disturbances and climate change

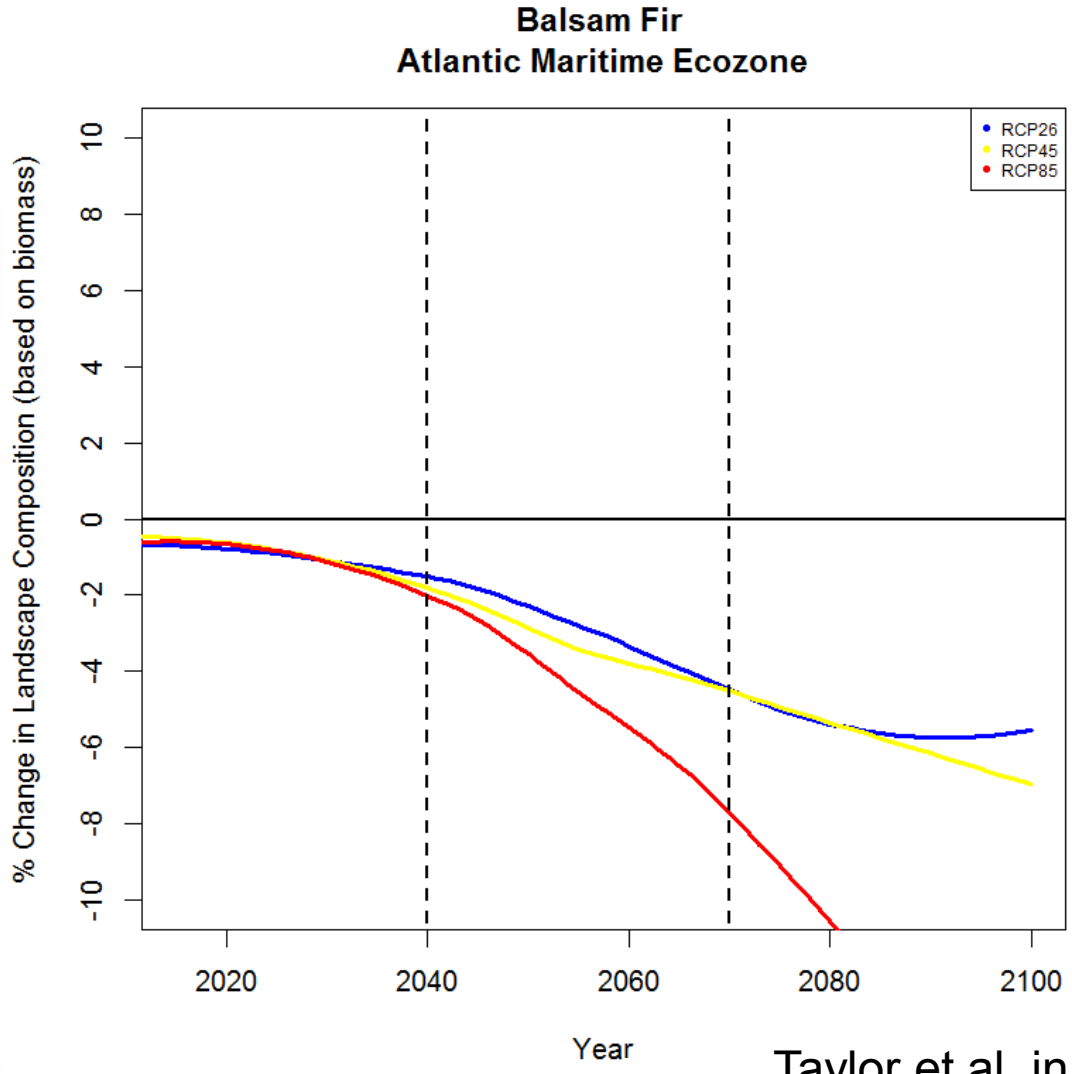


Study area

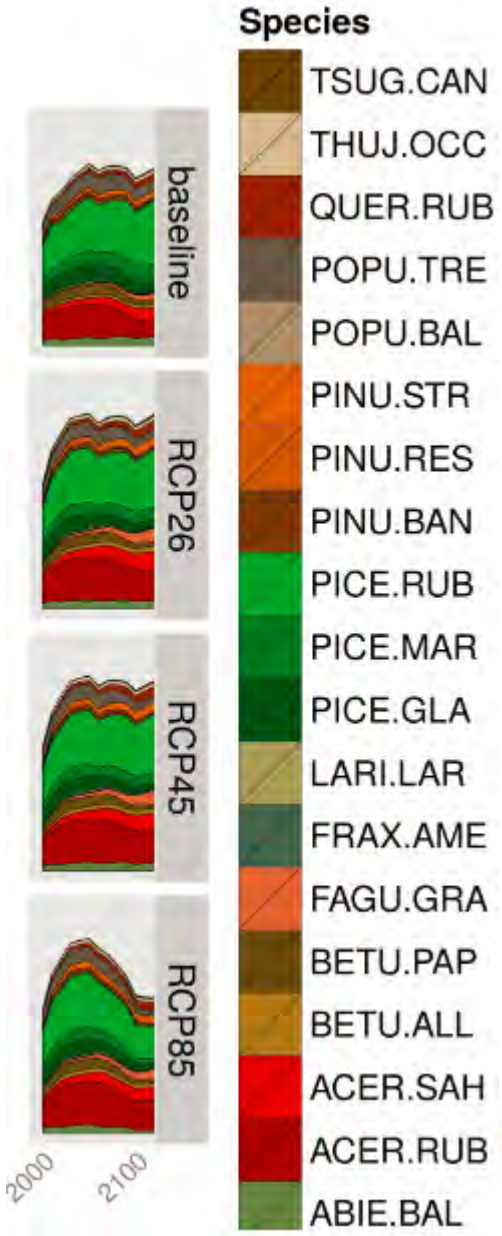
- Mix of coniferous and deciduous tree species
  - Spruce (black, red, white)
  - Balsam fir
  - Pine (white, red)
  - Maple (red, sugar)
  - American beech
  - yellow birch
- Recurrent spruce budworm
- Wildfires are rare
- Predicted habitat of BITH (Hart et al. unpubl. report)

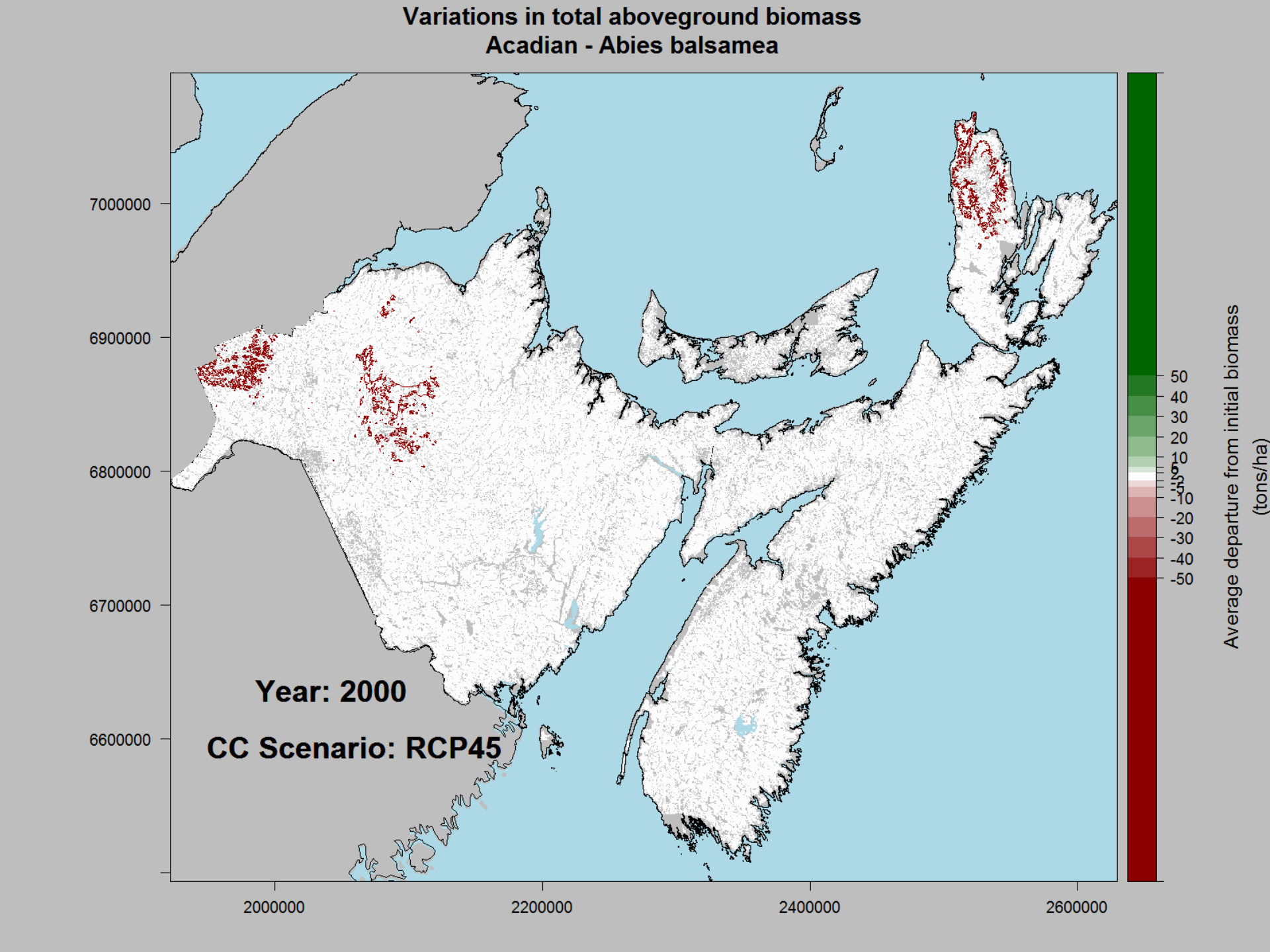


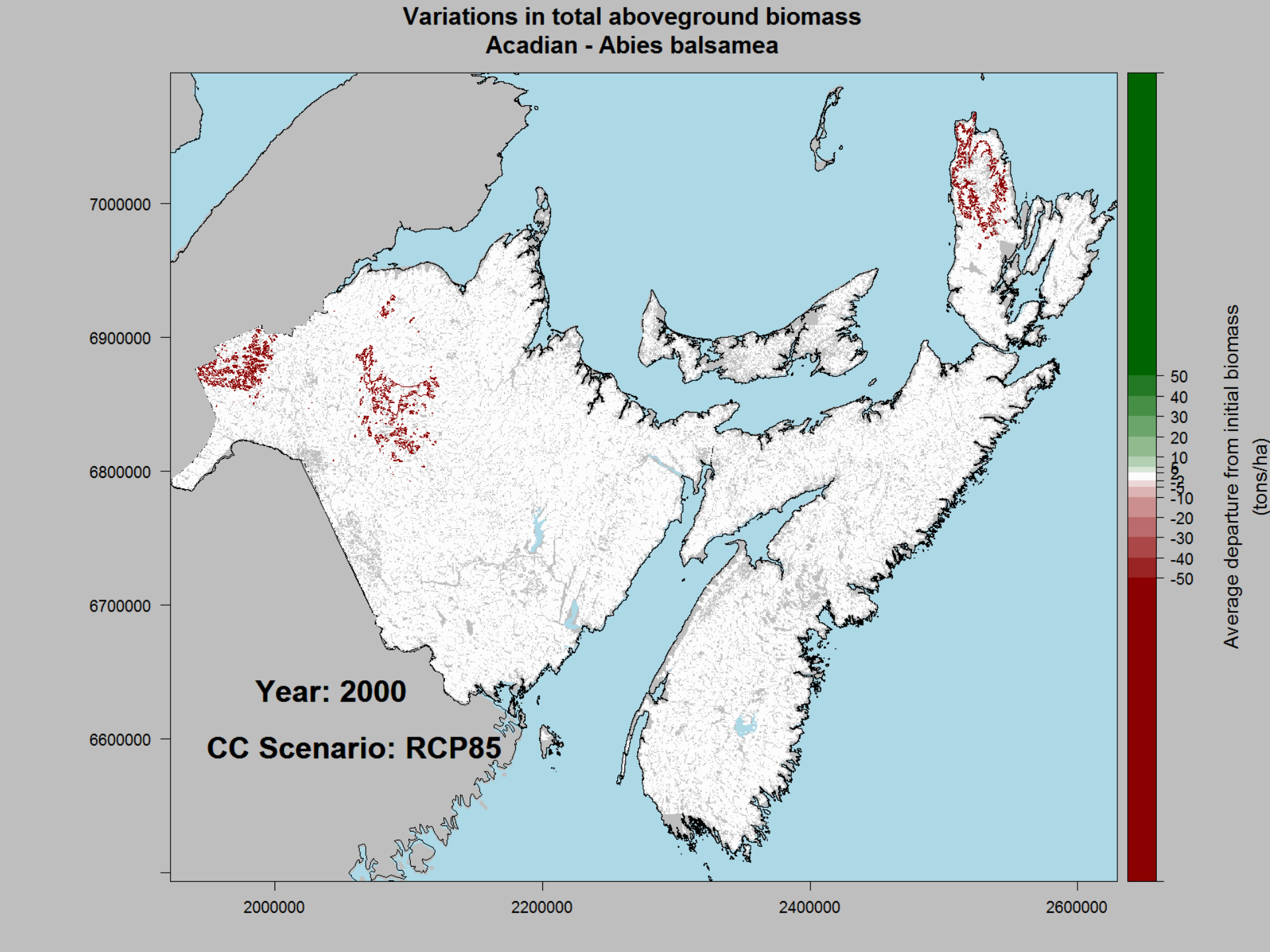
Results - Coniferous tree species



Taylor et al. in prep




Variations in total aboveground biomass
Acadian - Abies balsamea
Year: 2000
CC Scenario: RCP45
Average departure from initial biomass
(tons/ha)
50
40
30
20
10
5
-5
-10
-20
-30
-40
-50
7000000
6900000
6800000
6700000
6600000
2000000
2200000
2400000
2600000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2200000
2400000
2600000
Year: 2000
CC Scenario: RCP85
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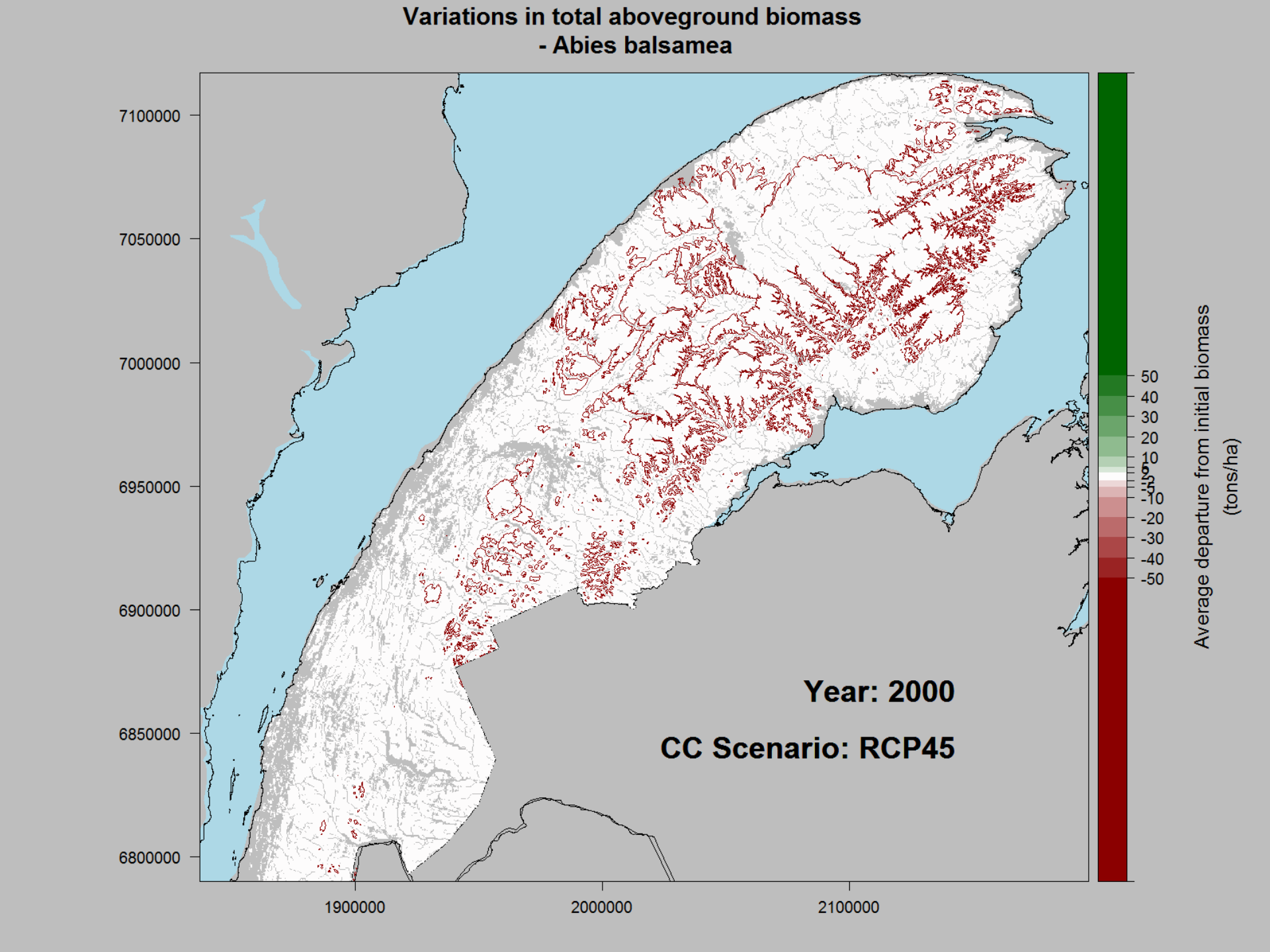
-40
-50
Average departure from initial biomass
(tons/ha)


Variations in total aboveground biomass
- Abies balsamea
7100000
7050000
7000000
6950000
6900000
6850000
6800000
1900000
2000000
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Year: 2000
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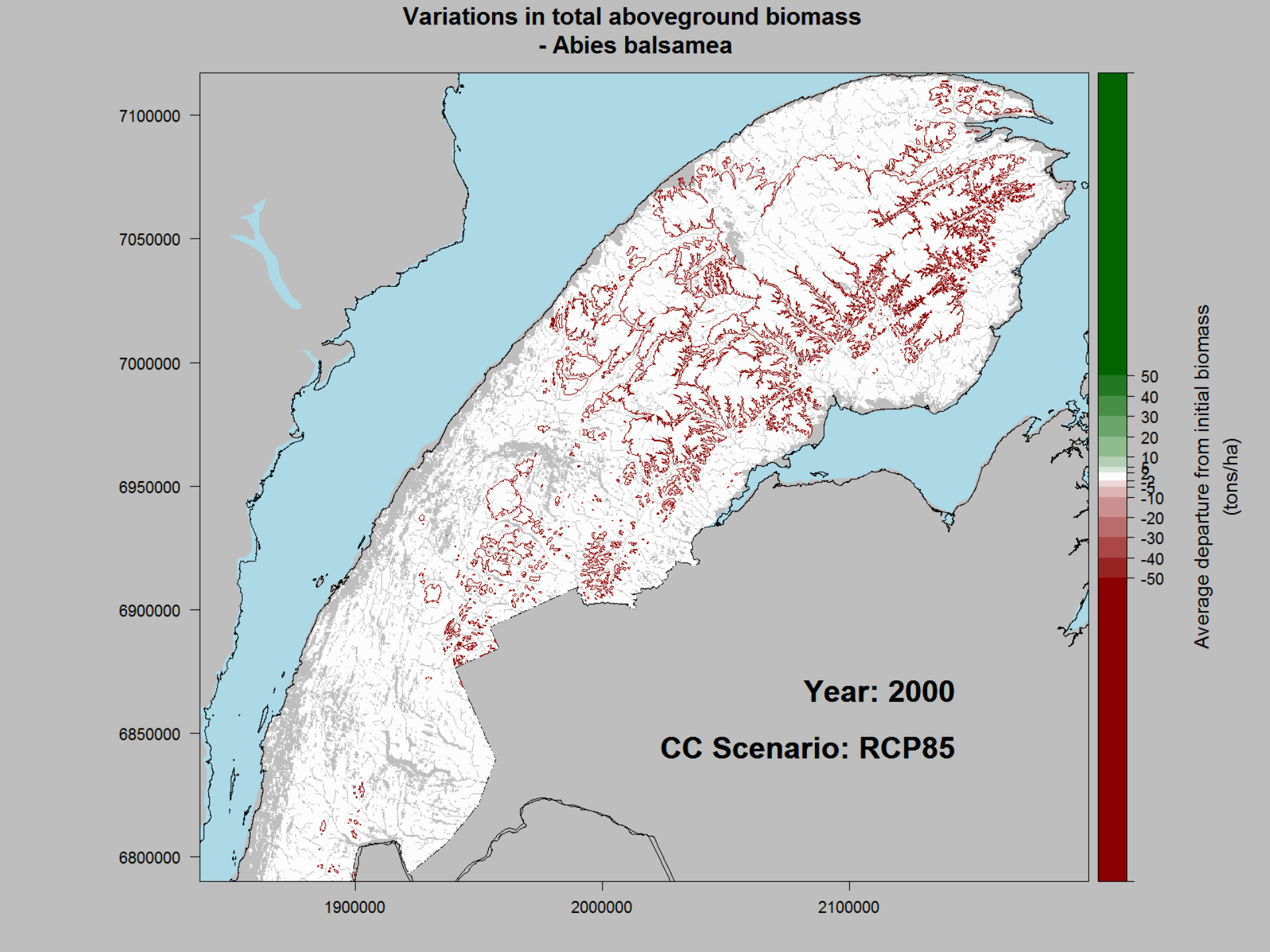
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Average departure from initial biomass
(tons/ha)
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10
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-5
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-20
-30
-40
-50

Discussion

- Impacts of climate change on BITH habitat
  - vary regionally
  - climatic conditions may favour balsam fir growth in higher altitude in the 2000-2070 period in RCP 4.5 scenario
  - Pessimistic scenario (RCP 8.5) present sharp decline in balsam fir biomass around 2080 mostly caused by wildfire
- Further work on critical habitat of BITH
  - Targeting density of balsam fir stems rather than only biomass
  - Management and conservation scenarios
- Need to evaluate climate change impact on recovery of species at risk
  - At the best of my knowledge, adaptation is not part of recovery plan for most of the species

Conclusion

- Decreasing biomass of boreal trees induces changes in boreal bird habitats which are amplified by
  - Natural disturbances (wildfires and spruce budworm outbreaks)
  - Anthropogenic disturbances (i.e. forest management)
- Importance of regional influences of natural and anthropogenic disturbances
- Forest management may be a great tool for adaptation to climate change in boreal forest
  - Adaptive management framework (Gauthier et al. 2014)
- Forest landscape models could be one of the tools used to test and plan management and conservation scenarios for the maintain of forest biodiversity

Next steps

1. Boreal bird habitats
   - BBWO: Increase to the north study area of LSJ (northern refuge)
   - Community level: Alberta (ABMI)
2. Critical habitat
   - Improve BITH model
   - Initiate CAWA model
   - Others?

Thanks !

For further details:

- Junior A. Tremblay
  - Environment and Climate change Canada
  - Junior.Tremblay@canada.ca

- Yan Boulanger
  - Natural Resources Canada
  - Yan.Boulanger@canada.ca