Impacts of changing North American boreal forest fire regimes on landscape composition and regional climate

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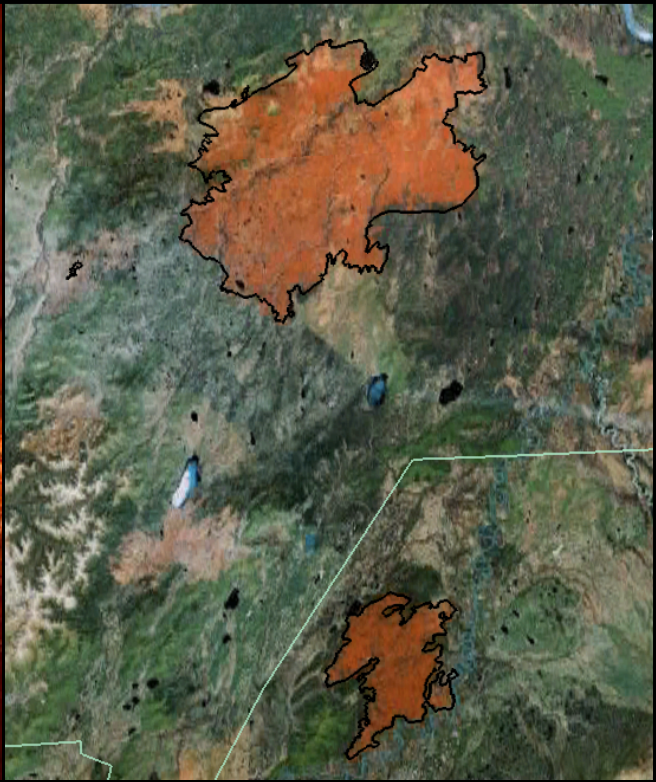
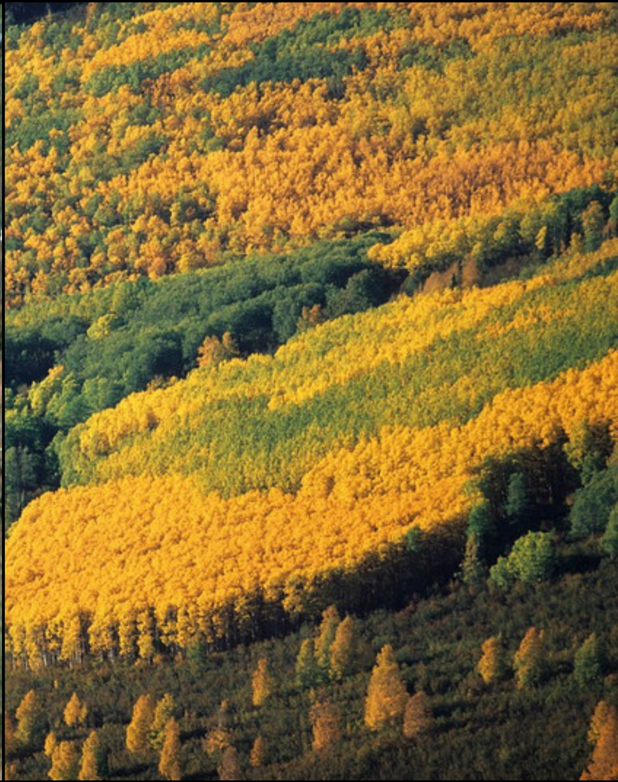
CCSM Joint Land and Biogeochemistry Working Group
March 1, 2011





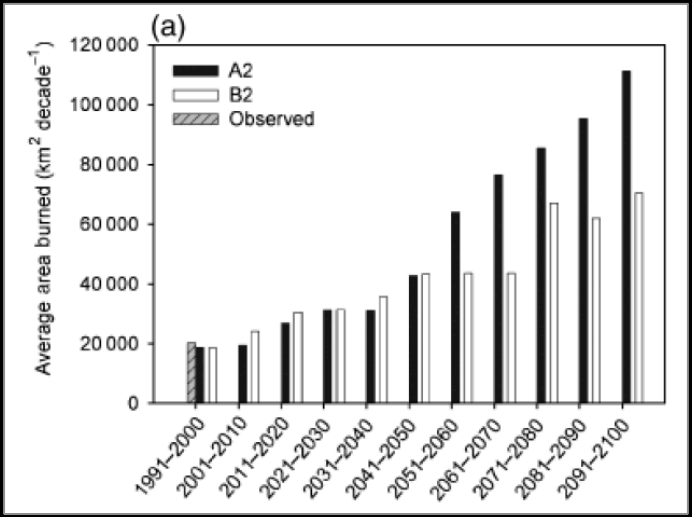
Introduction

Why vegetation from boreal forest fires?

- ΔT highest in high latitude systems
- potentially large feedbacks
  - GHGs & carbon
  - landscape biophysics
    - Δ snow
    - Δ lakes/wetlands/glaciers
    - Δ vegetation
      - migration (tundra)
      - disturbance (forest)

Why North America?

- most fires severe
- relatively homogenous ecology
- long-term data
- projections of large changes



Balshi et al. [2009]

Introduction

field plots

- *Amiro* [2001]
- *Chambers & Chapin* [2002]
- *Chambers et al.* [2005]
- *Liu et al.* [2005]
- *Liu & Randerson* [2008]
- *McMillan & Goulden* [2008]

upscaling

field syntheses

- *Amiro et al.* [2006]

regional trajectories

- *Lyons et al.* [2008]
- *Beck et al.* [2011]
- *Jin et al.* [2012]

radiative extrapolation

- *Randerson et al.* [2006]

continental modeling

This study

- data-driven fire and vegetation patterns
- prescribe succession and altered fire regimes
- simulate impacts on continental climate

global modeling

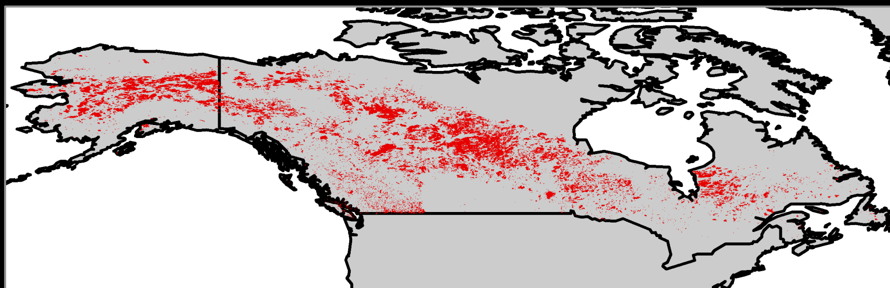
Future work

- Eurasia and North America
- prognostic fire
- dynamic vegetation
- aerosols and GHGs/ carbon balance
- simulate feedbacks under climate change

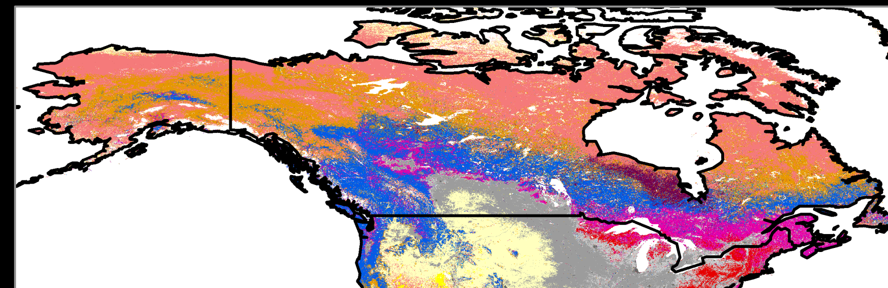
Succession Patterns

Succession Patterns

Large Fire Databases



MODIS Land Cover



Succession Patterns

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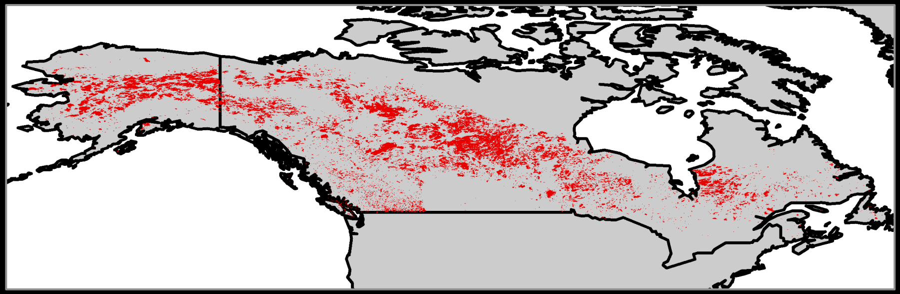

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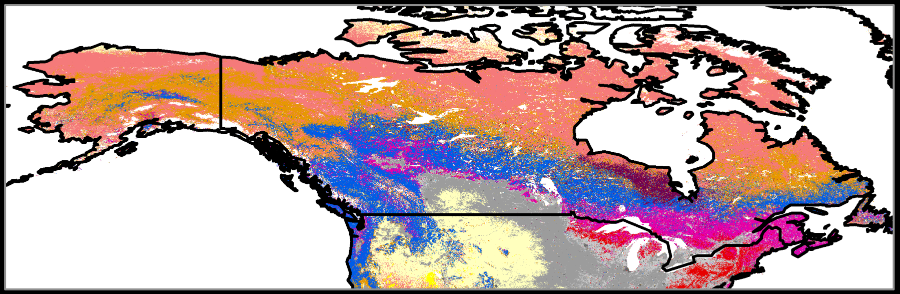

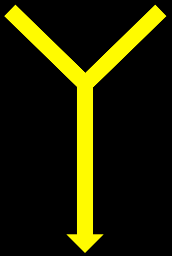

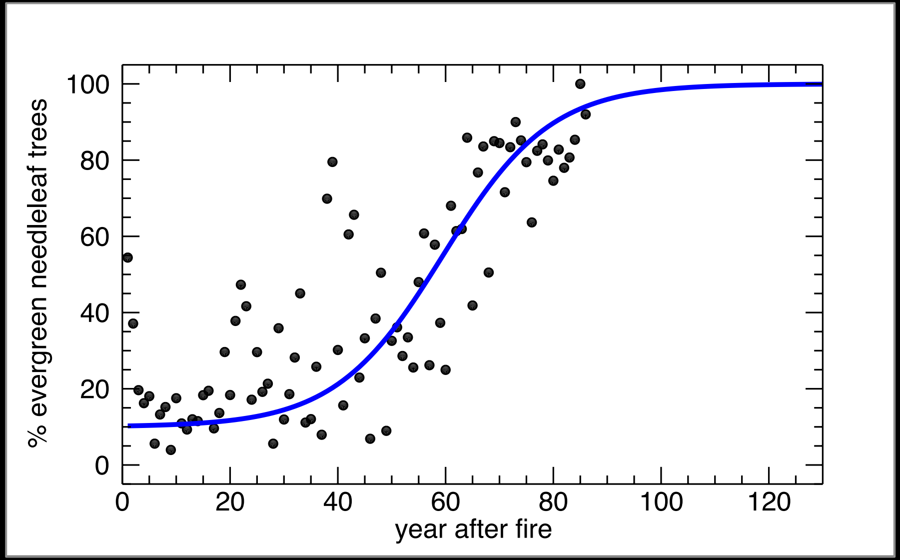

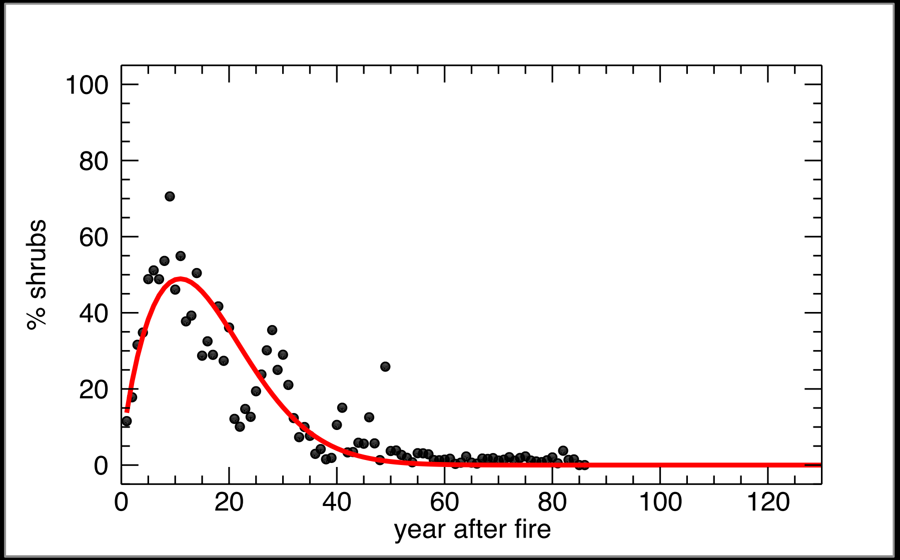

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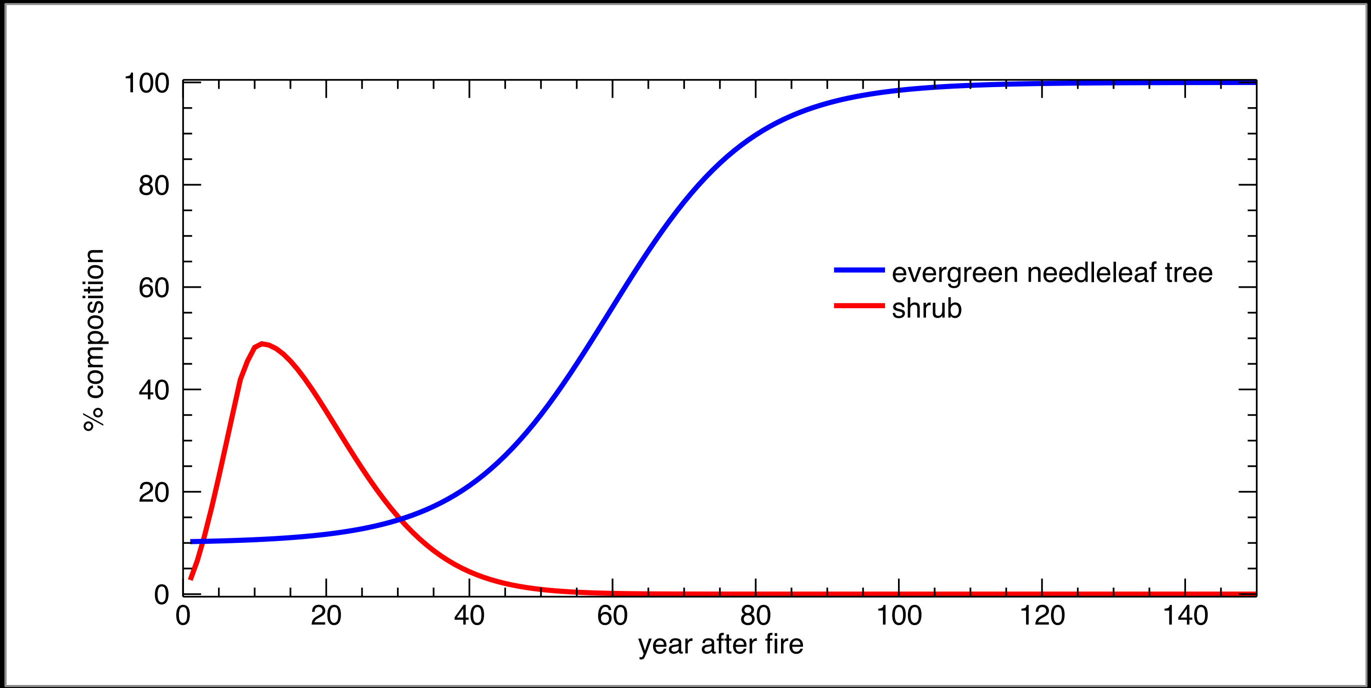

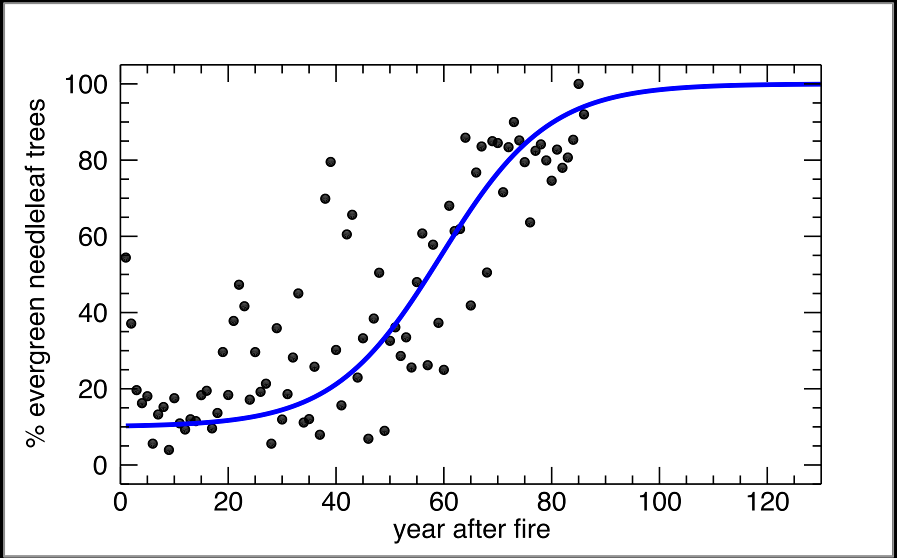

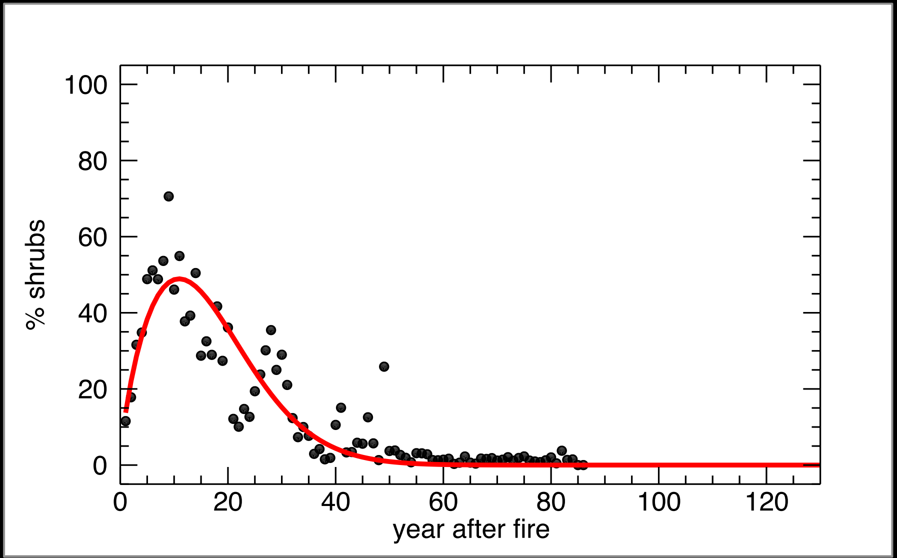

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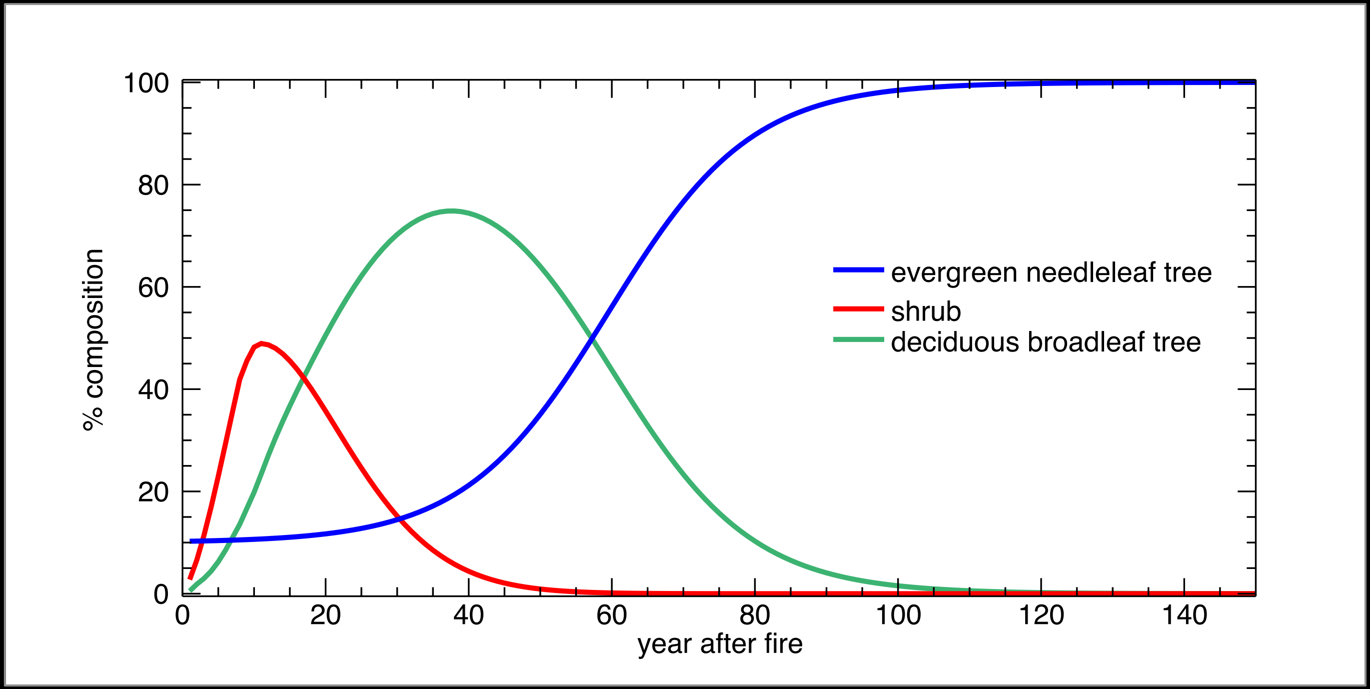

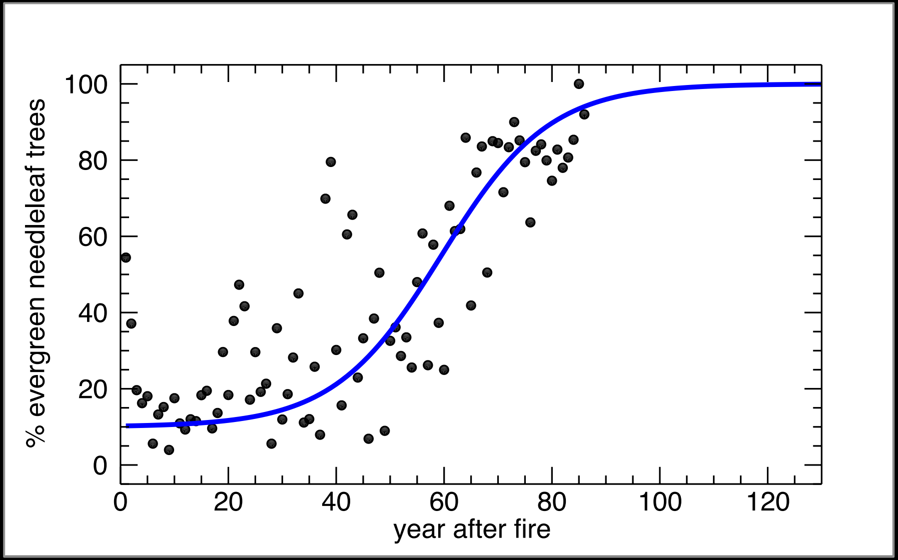

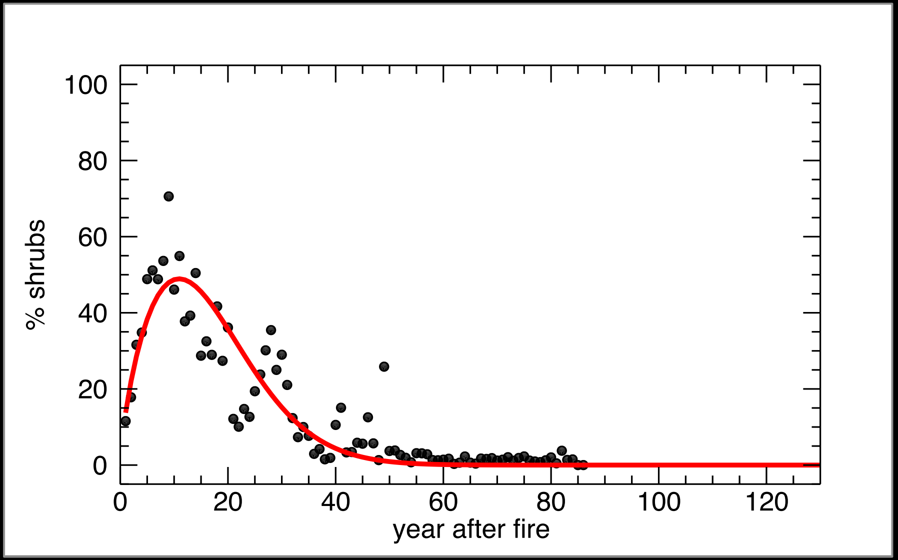

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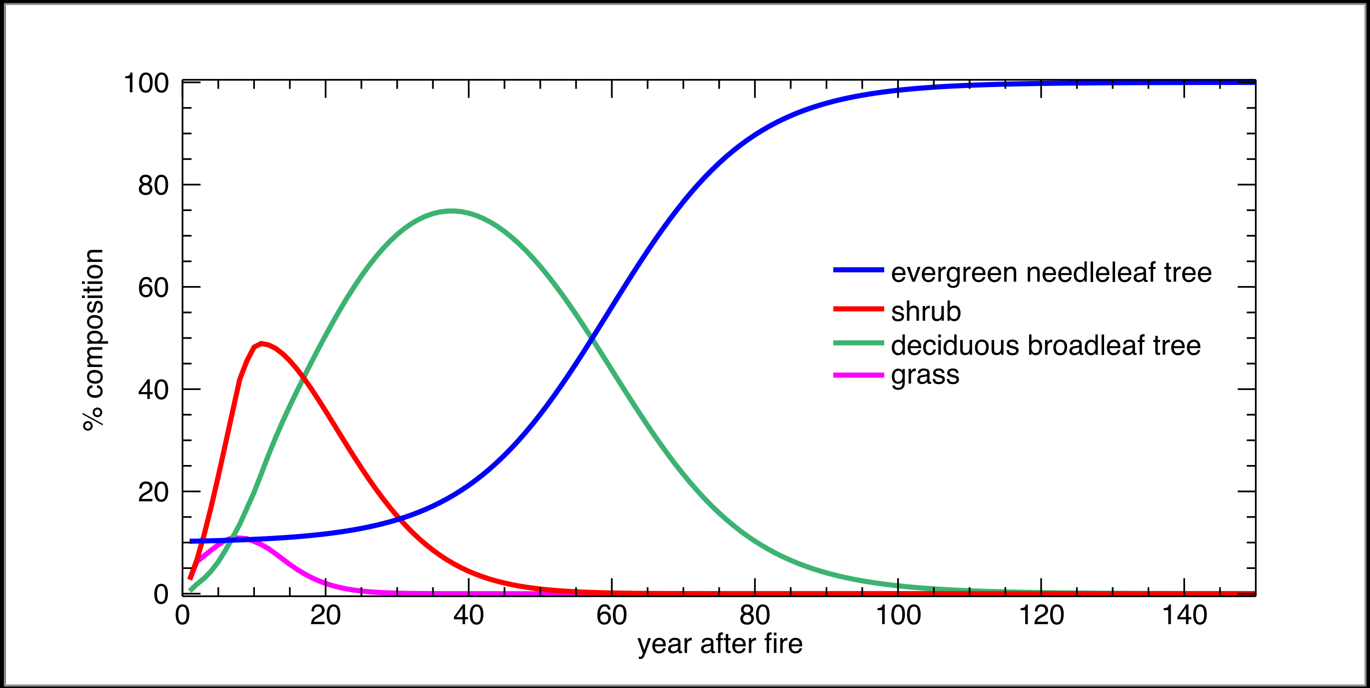

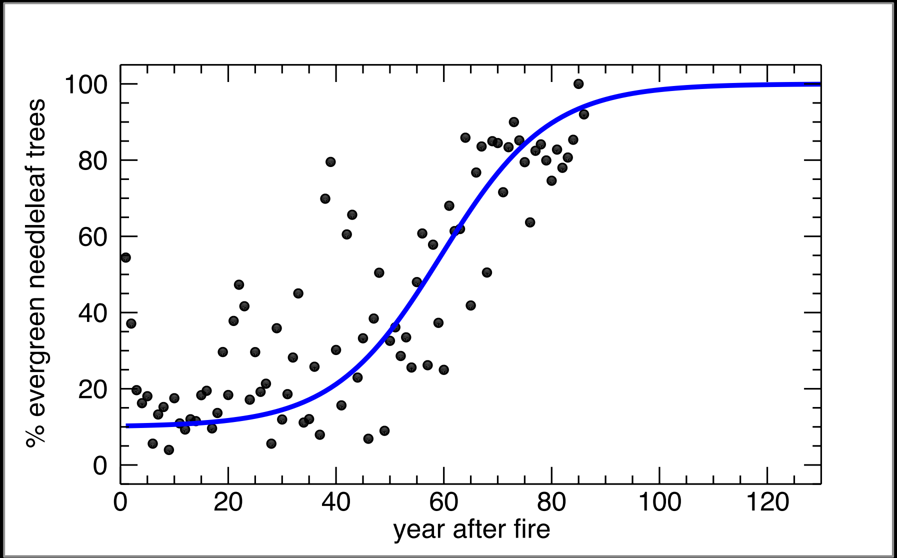

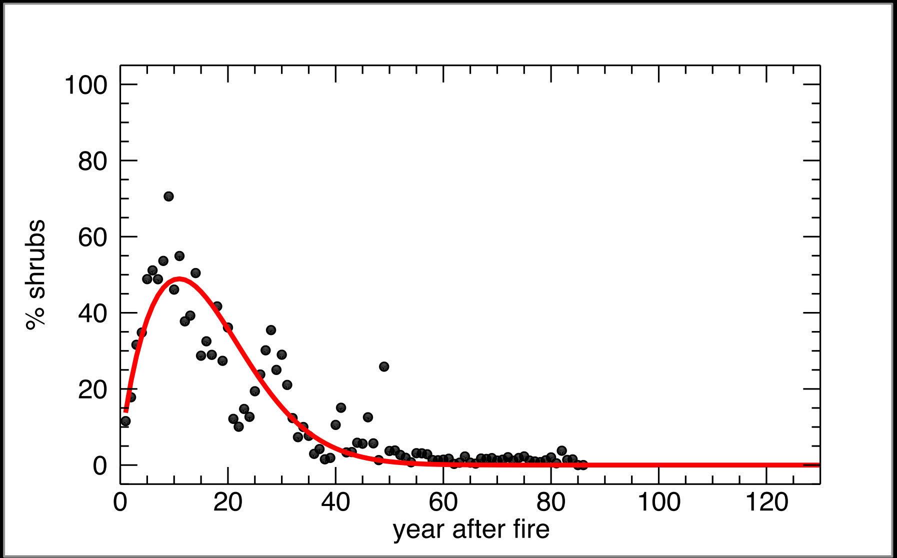

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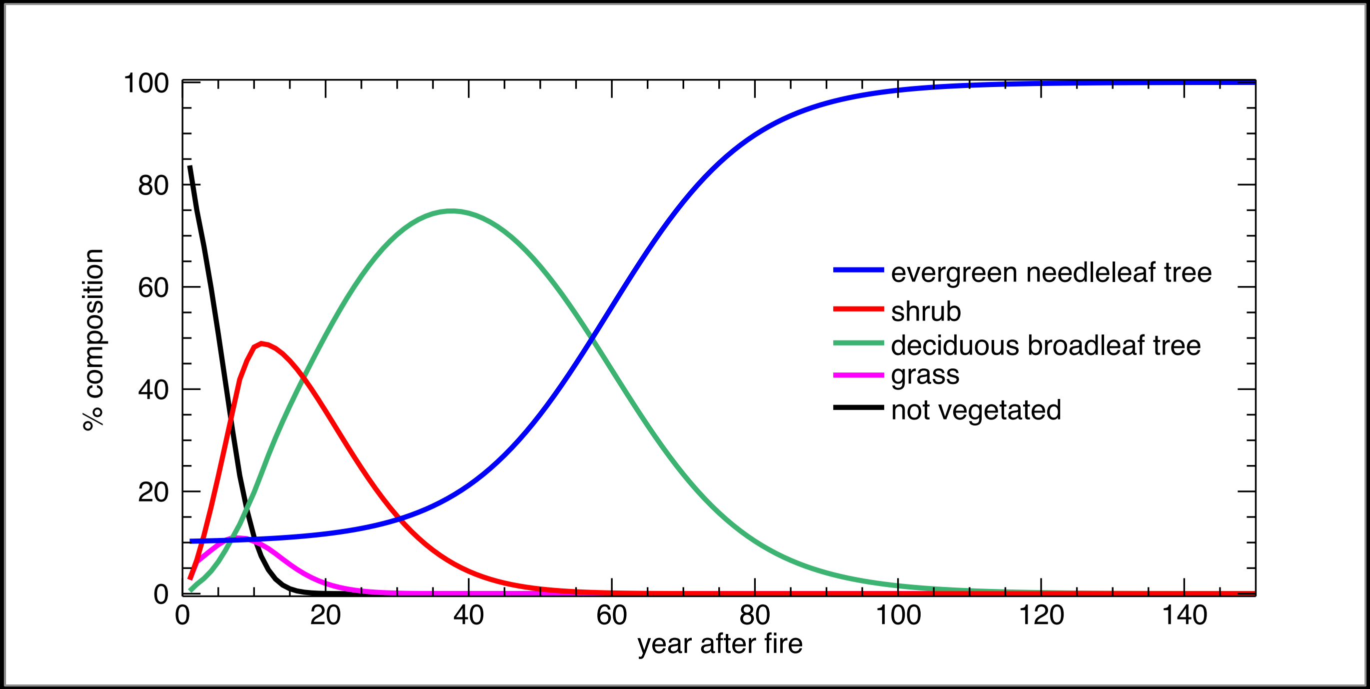

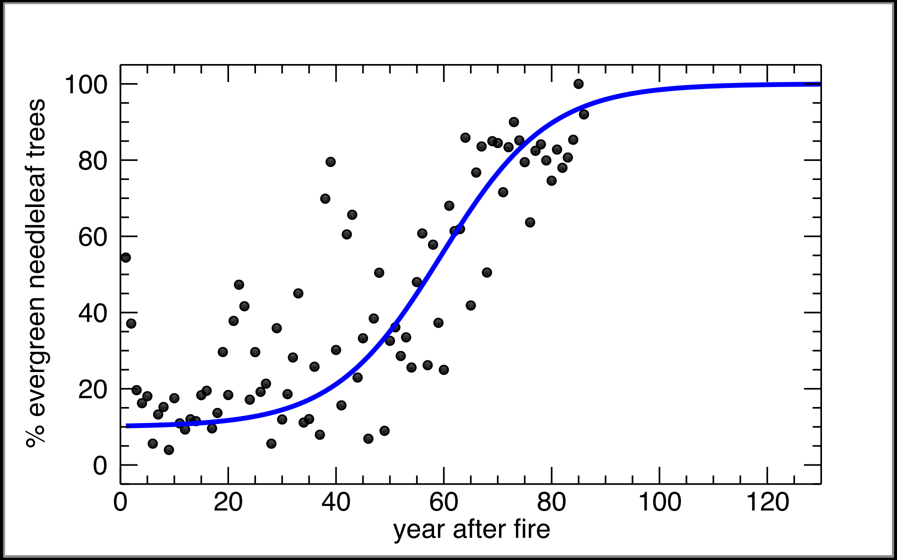

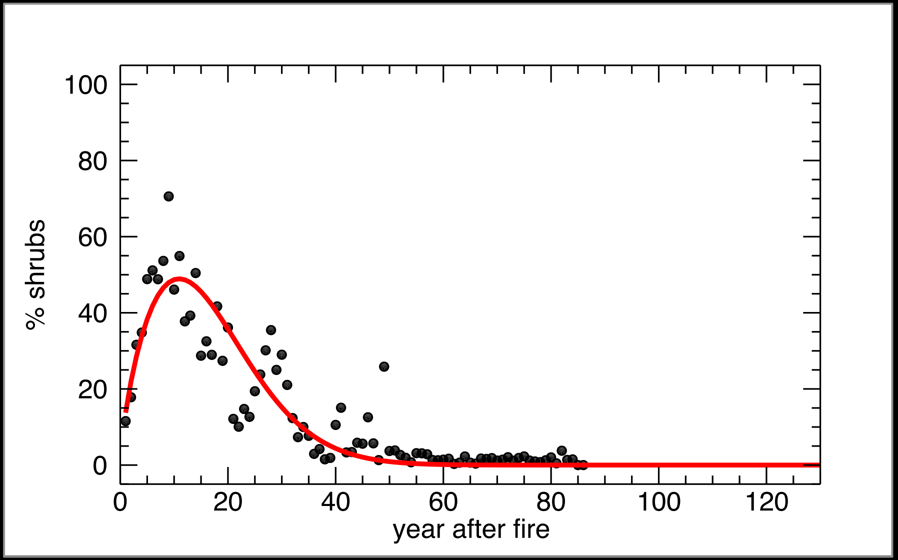

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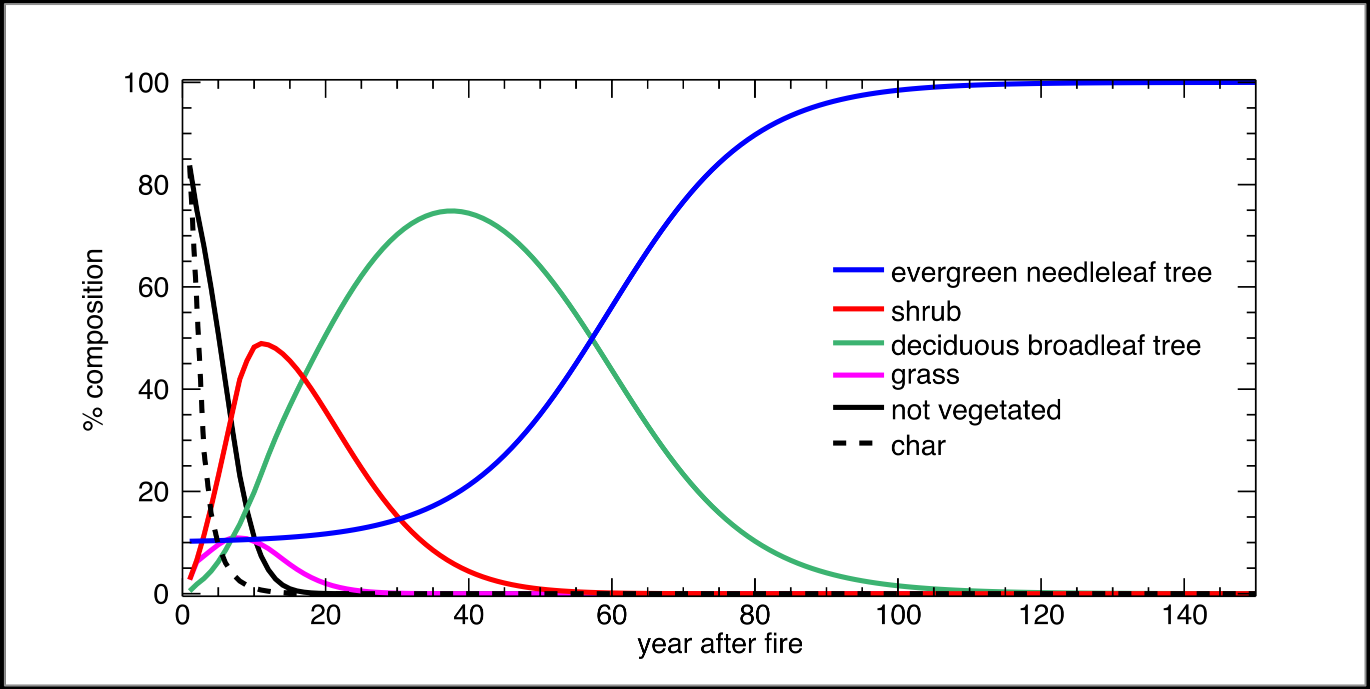

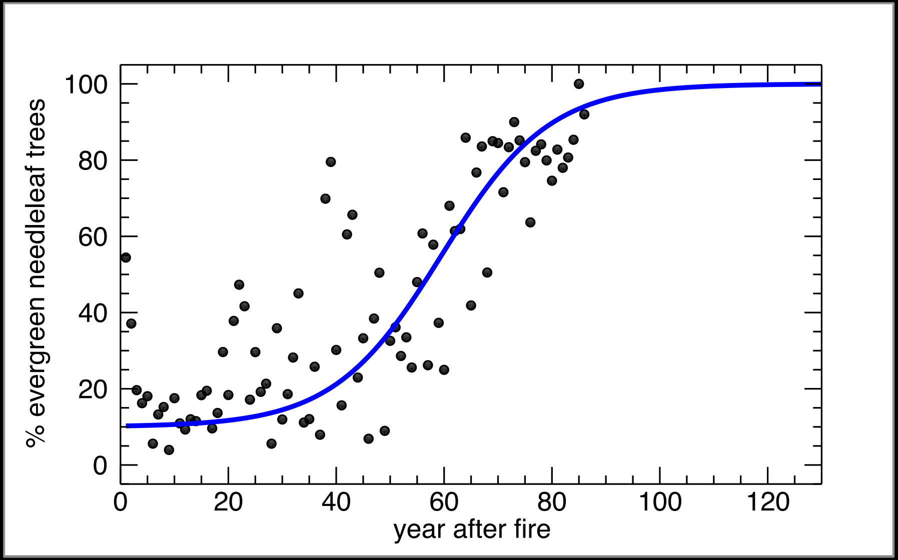

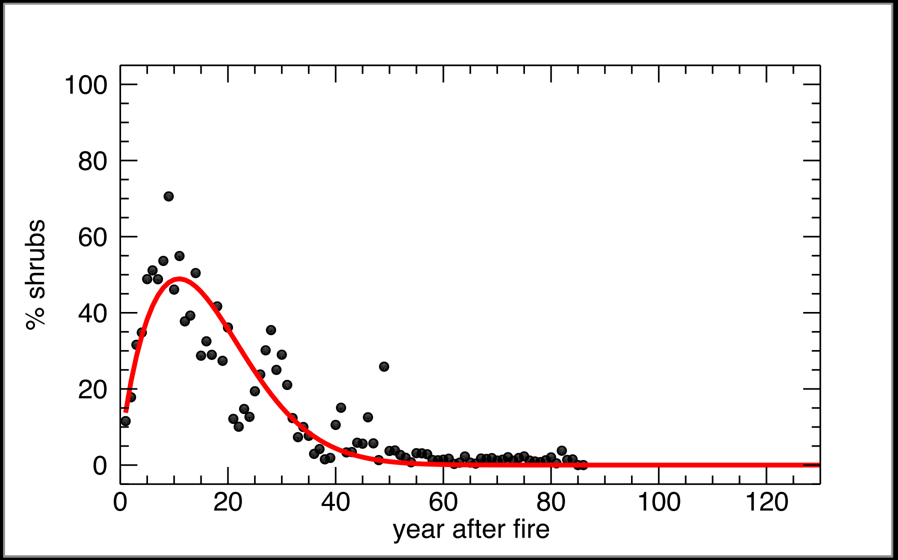

Validation: summer

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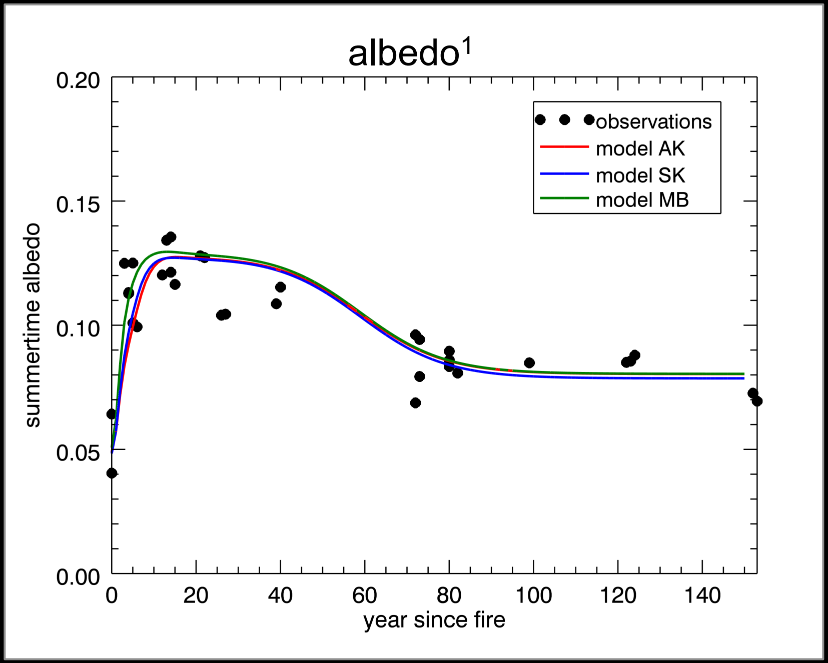

[1]observations from Amiro et al. [2006]

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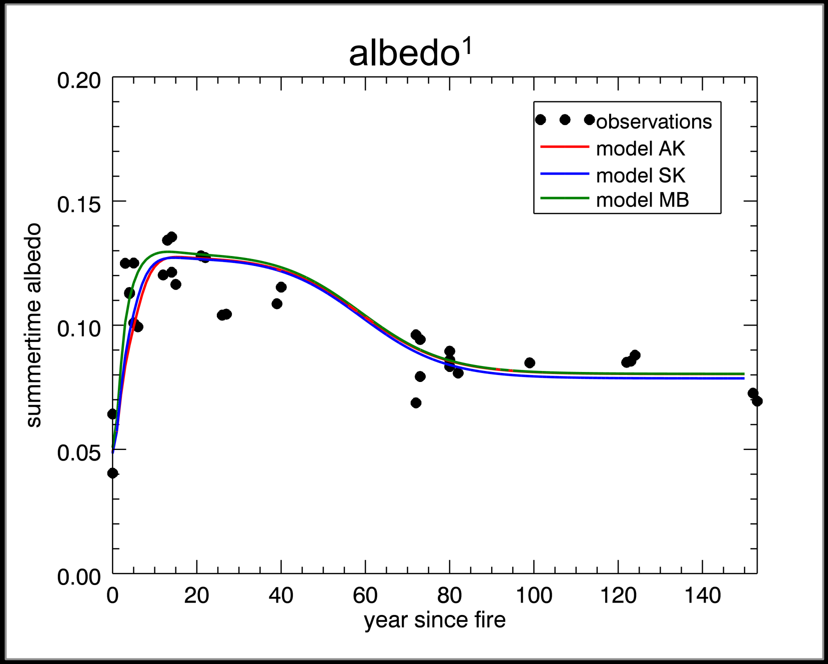

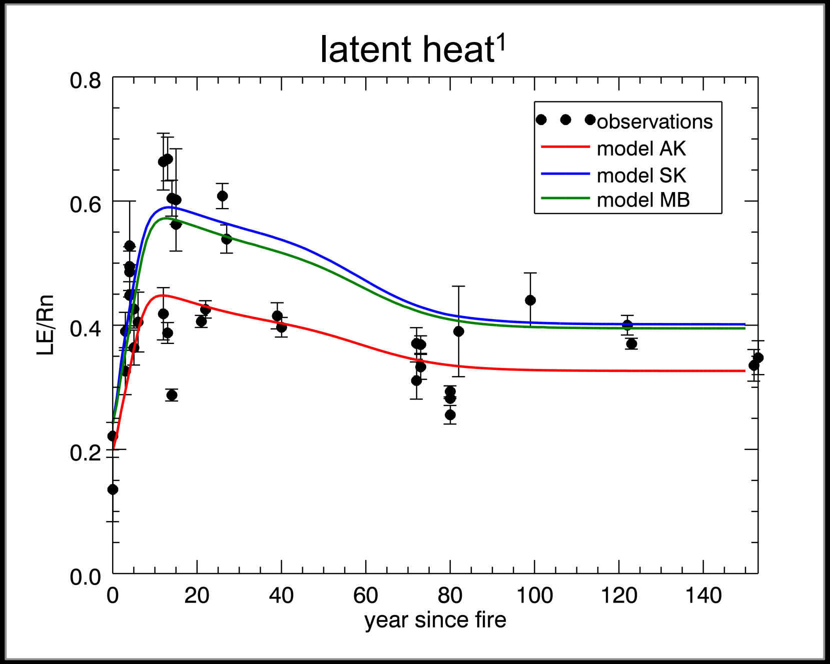

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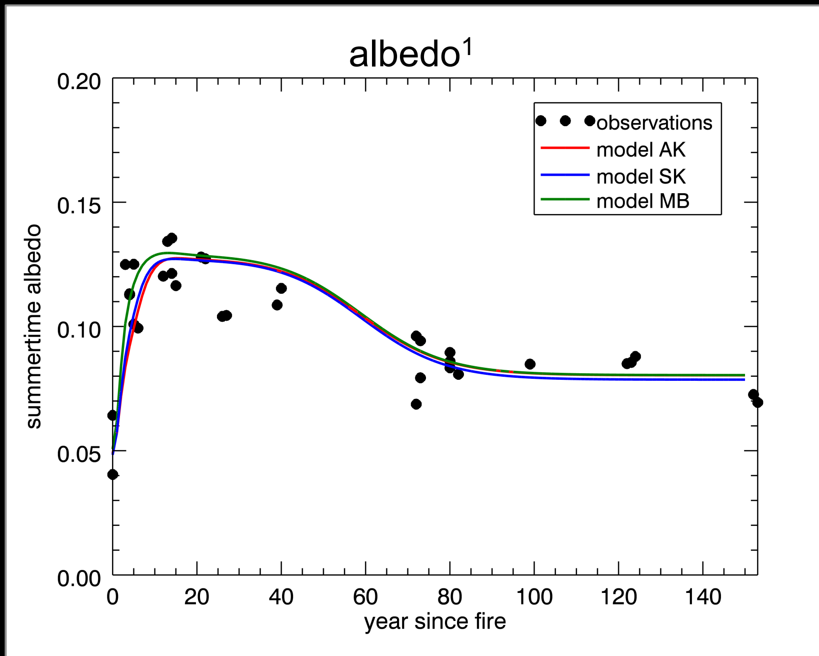

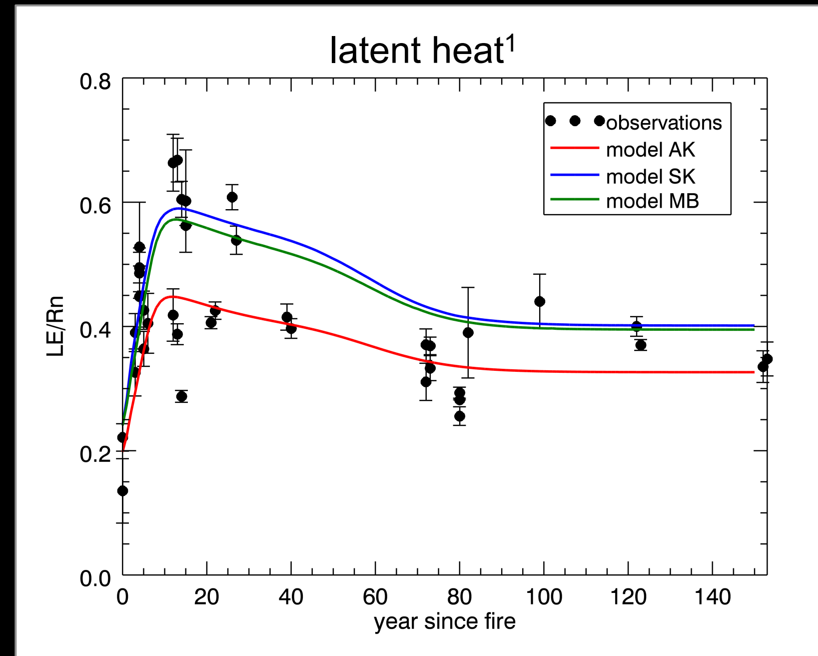

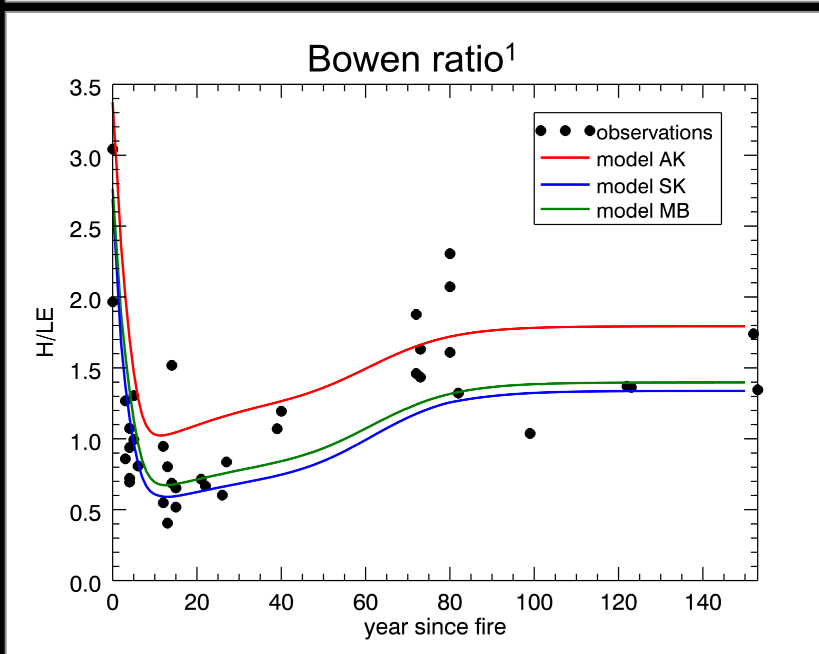

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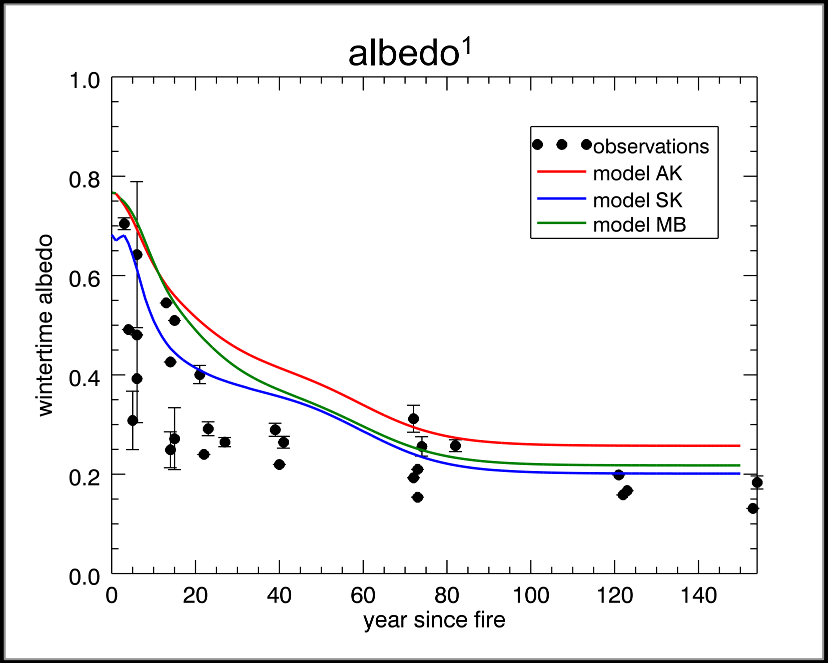

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[3]observations from *Liu & Randerson* [2008]

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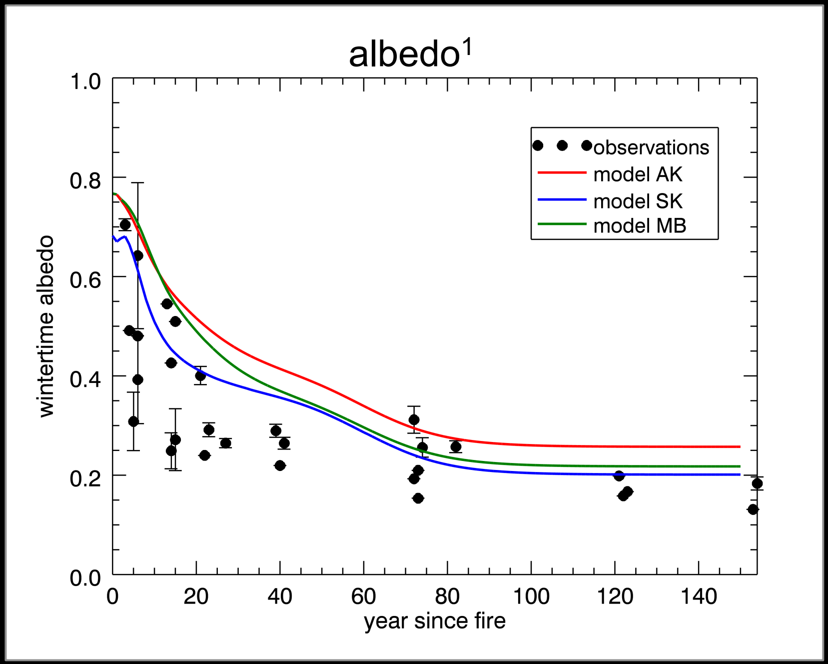

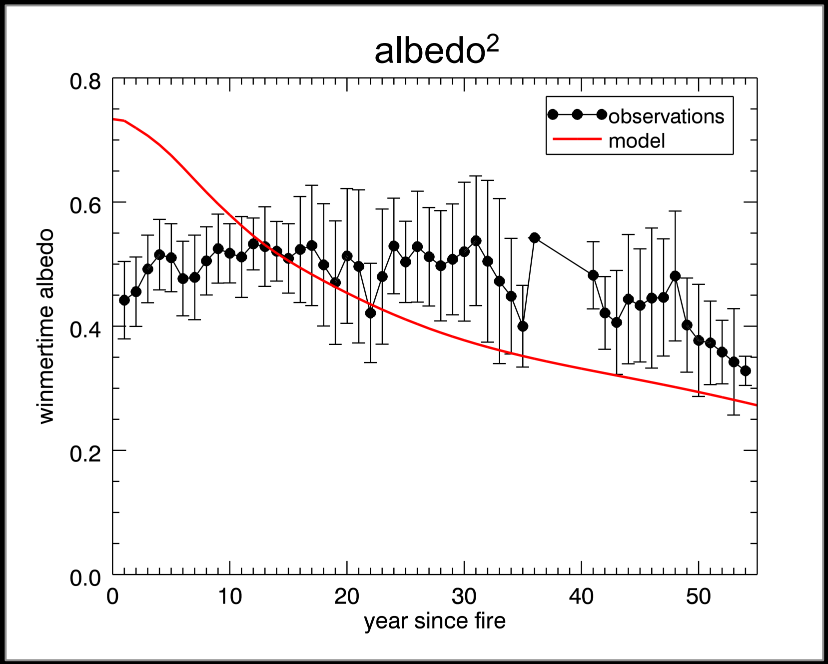

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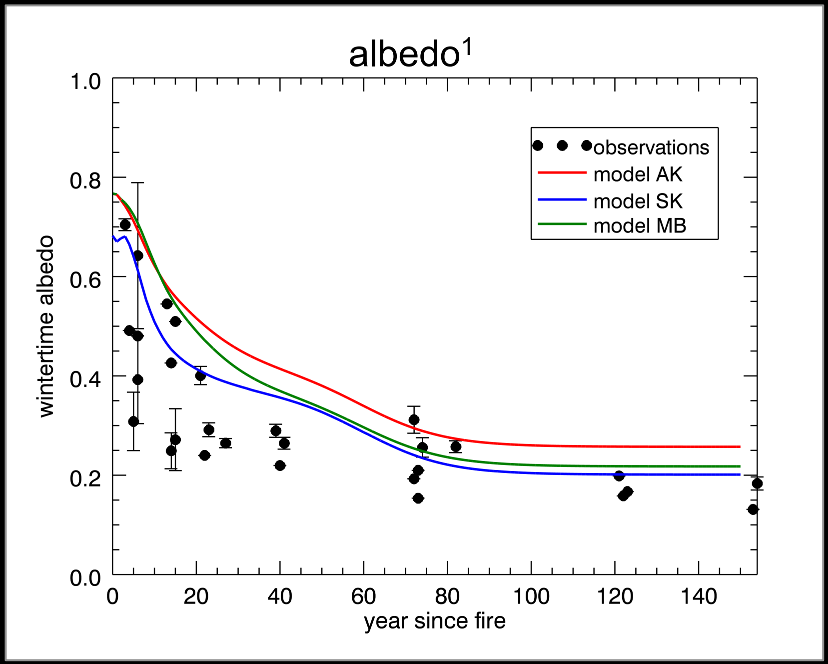

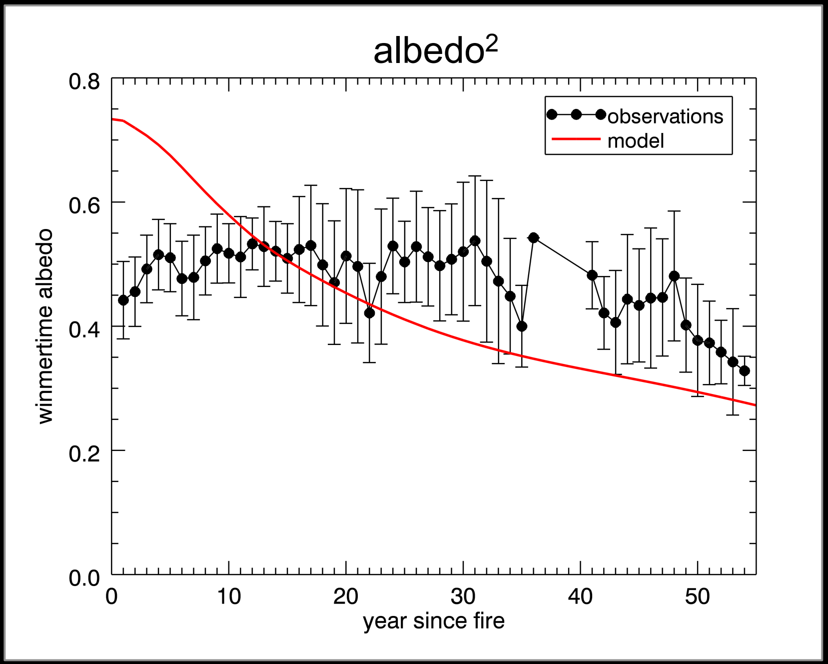

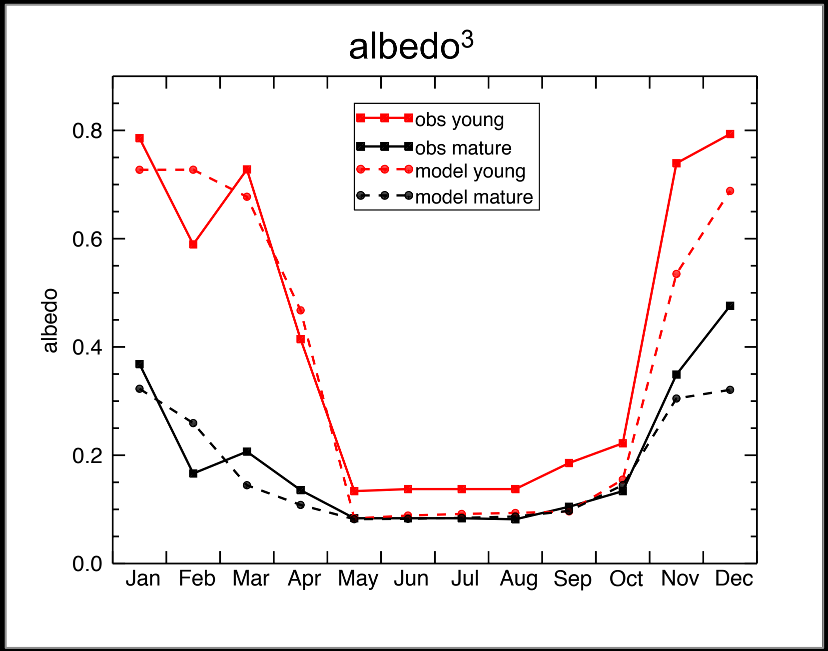

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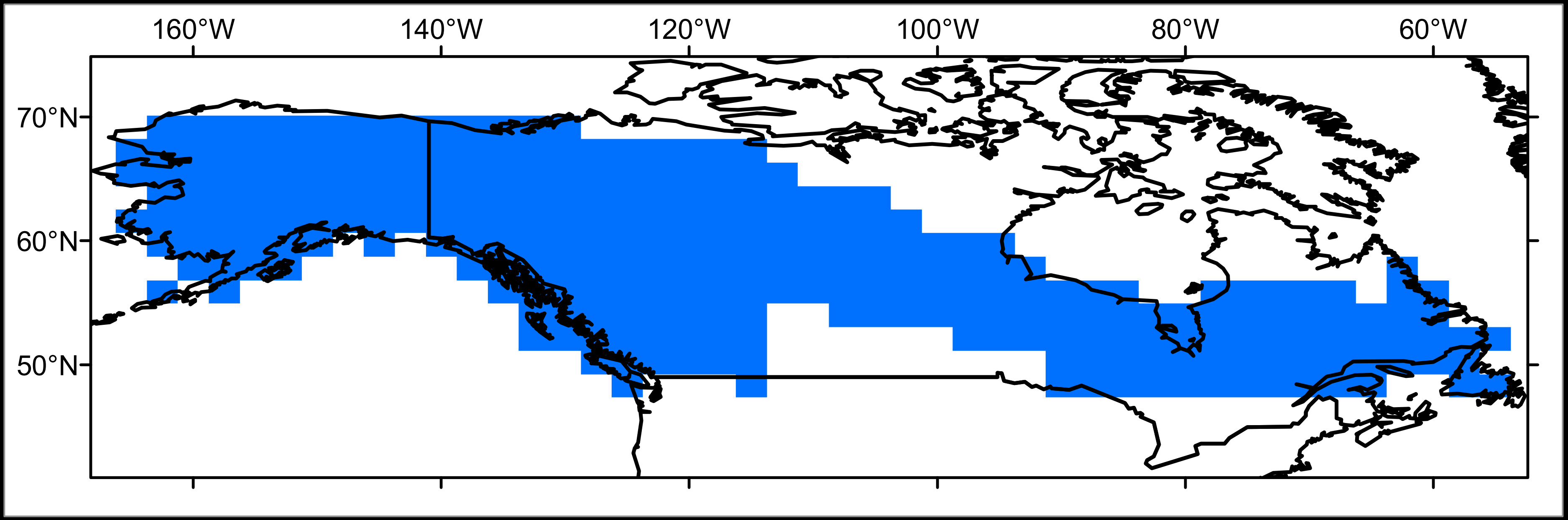
Domain Composition



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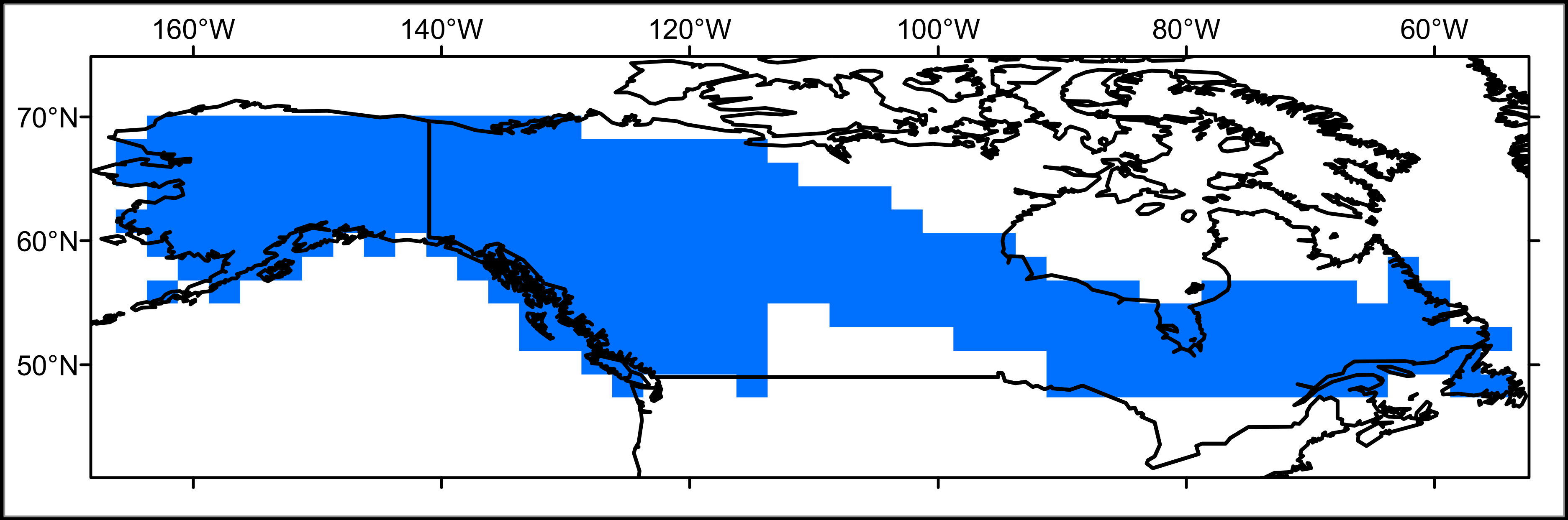

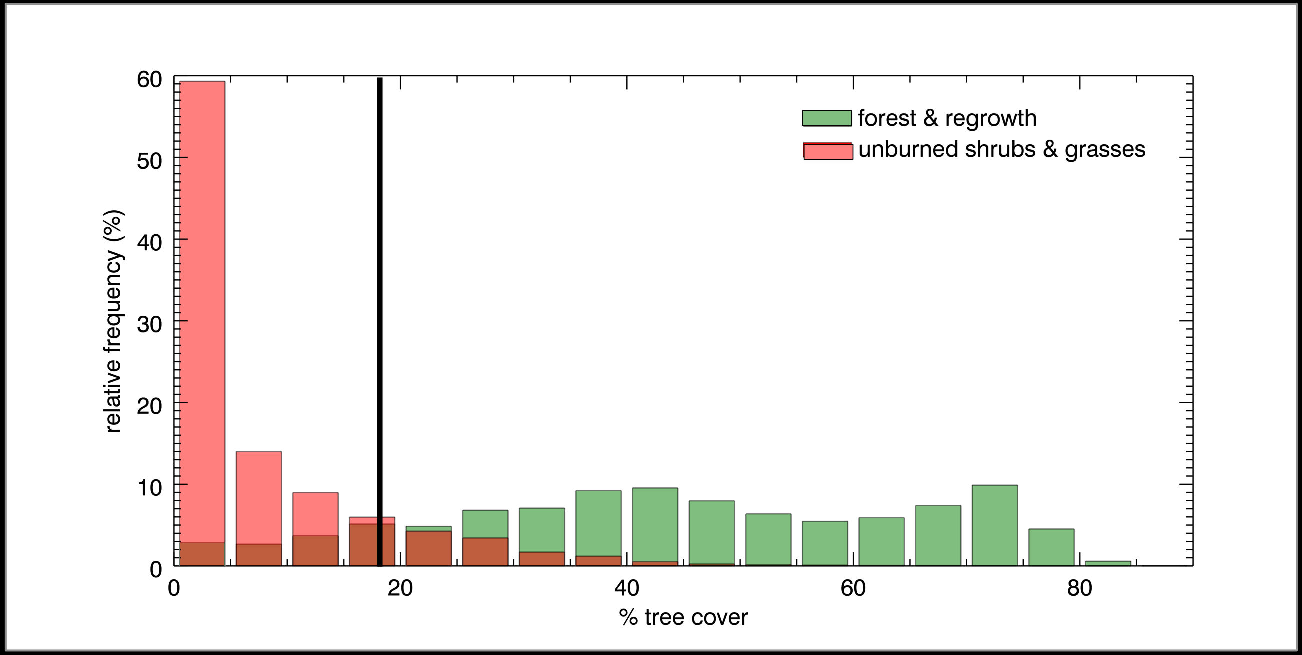

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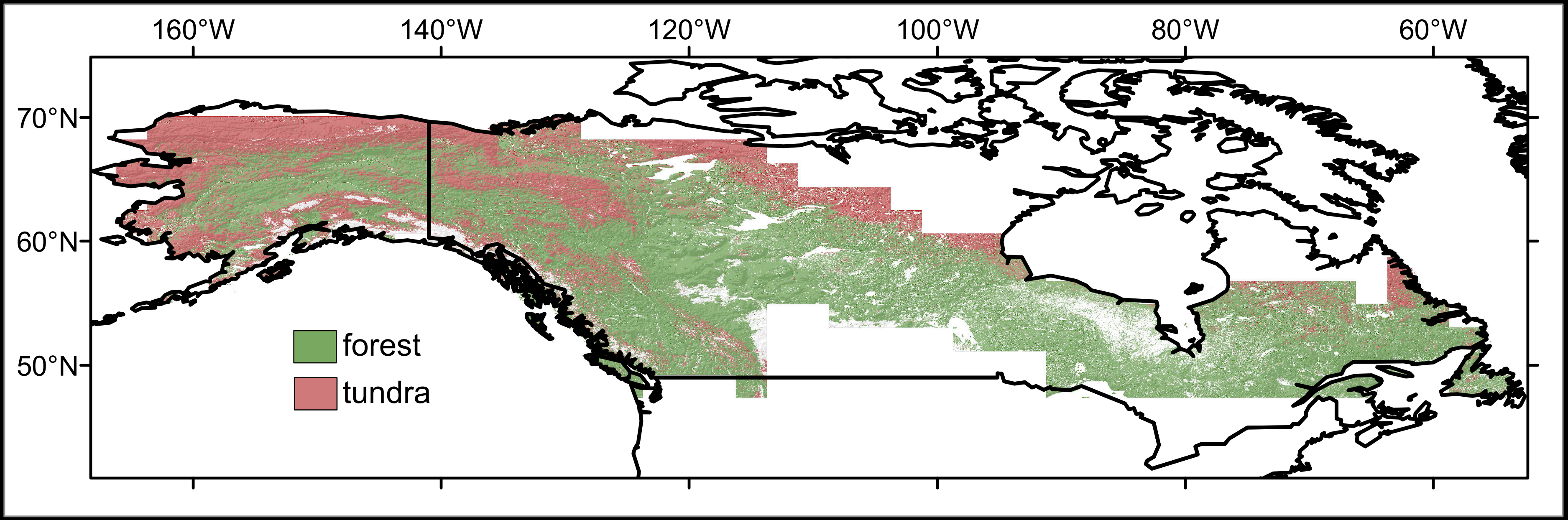

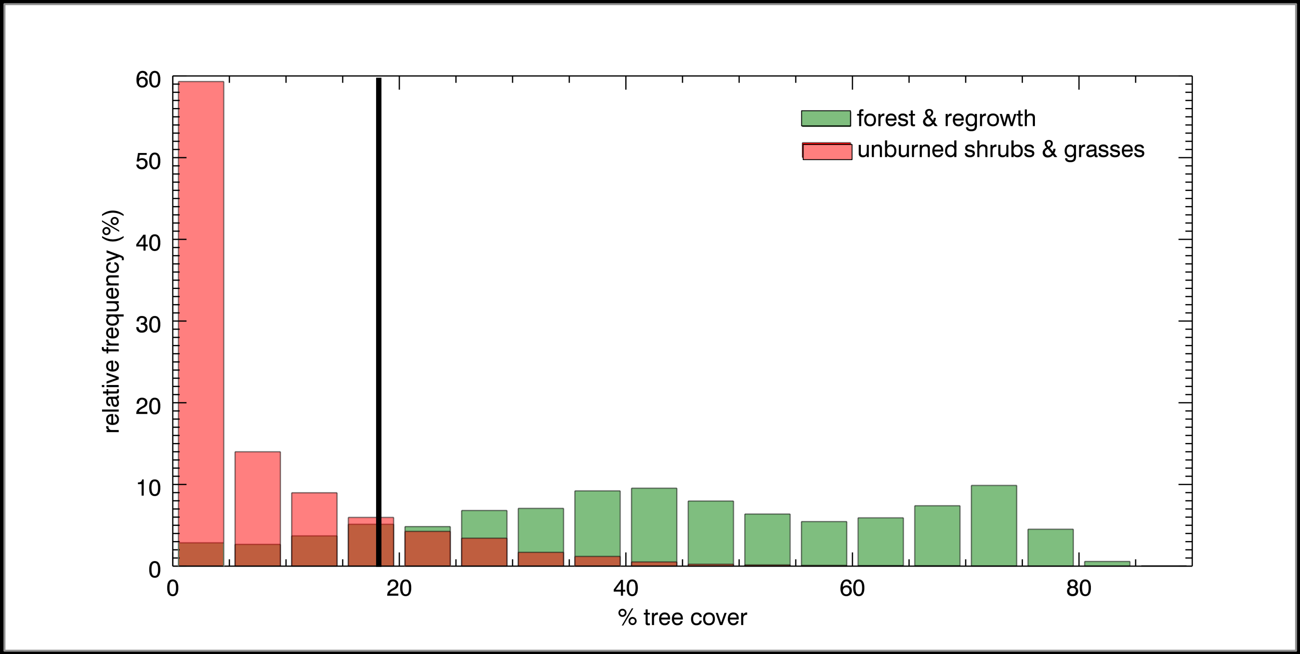

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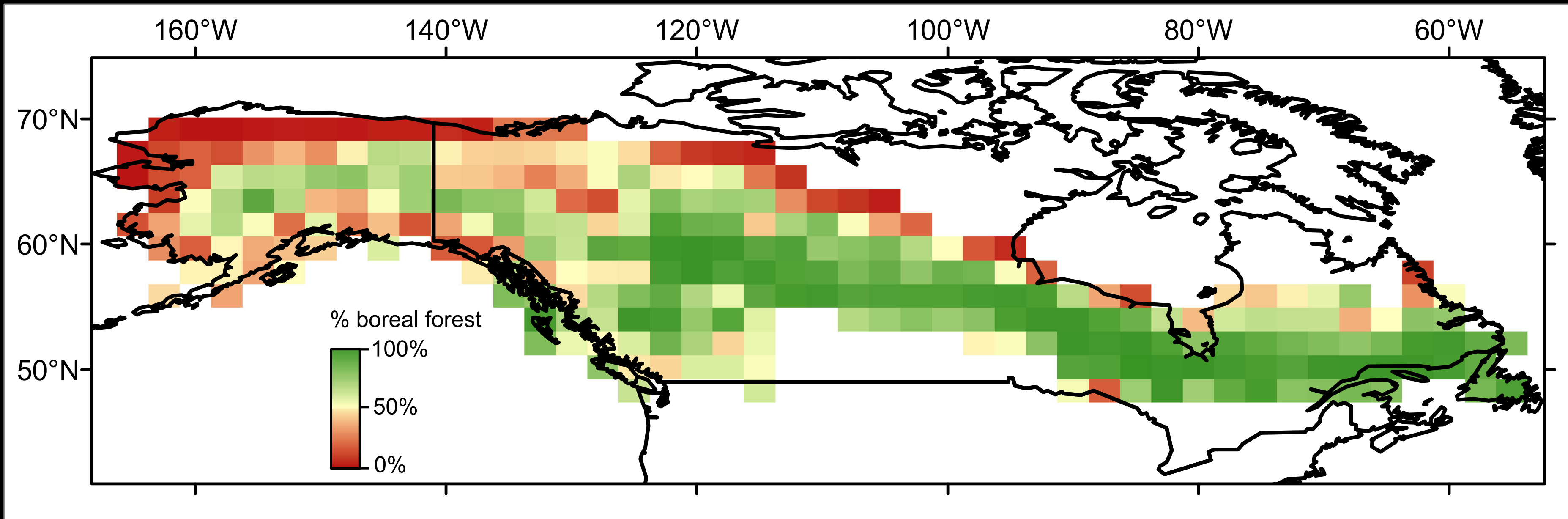
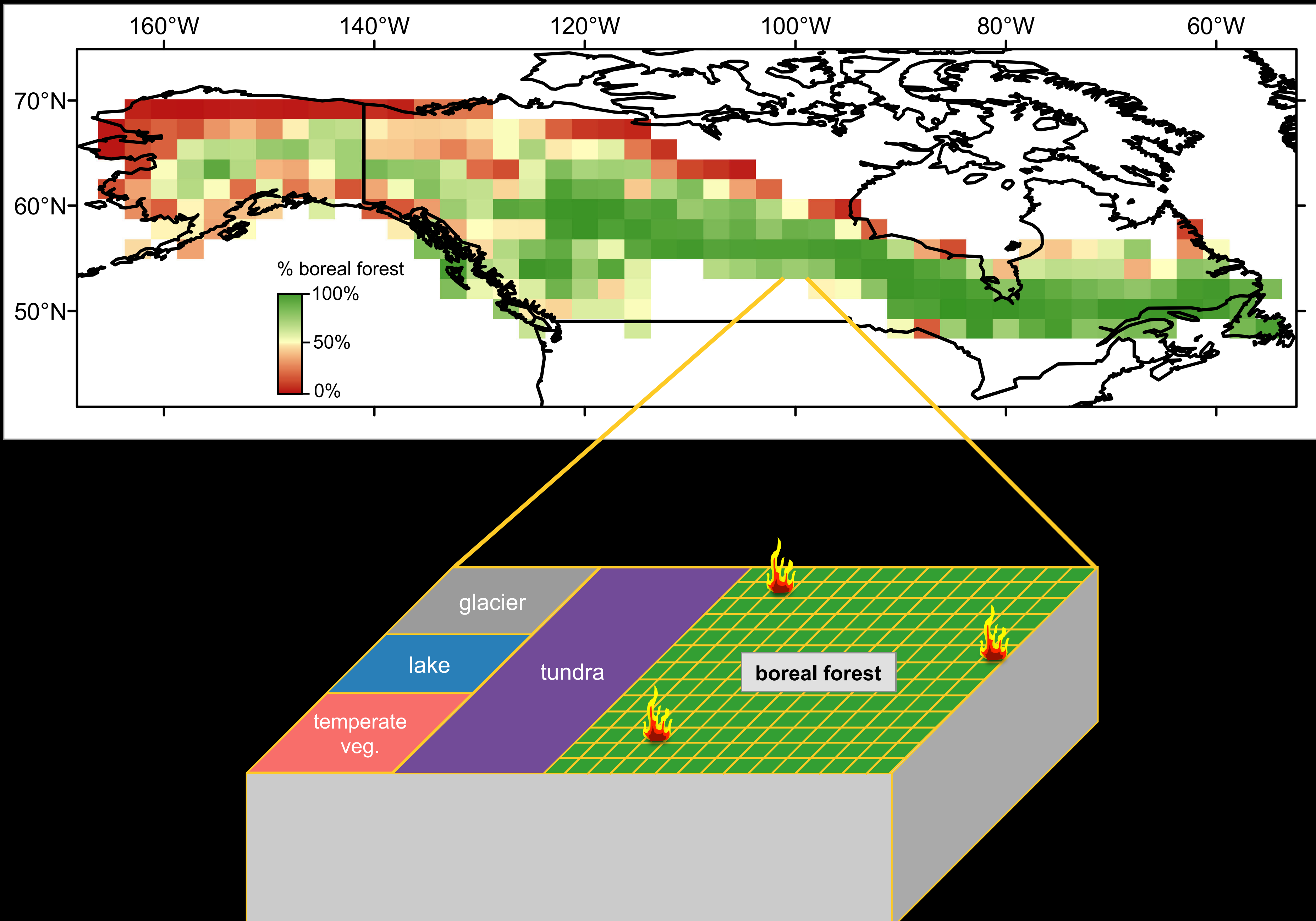


Offline Simulations



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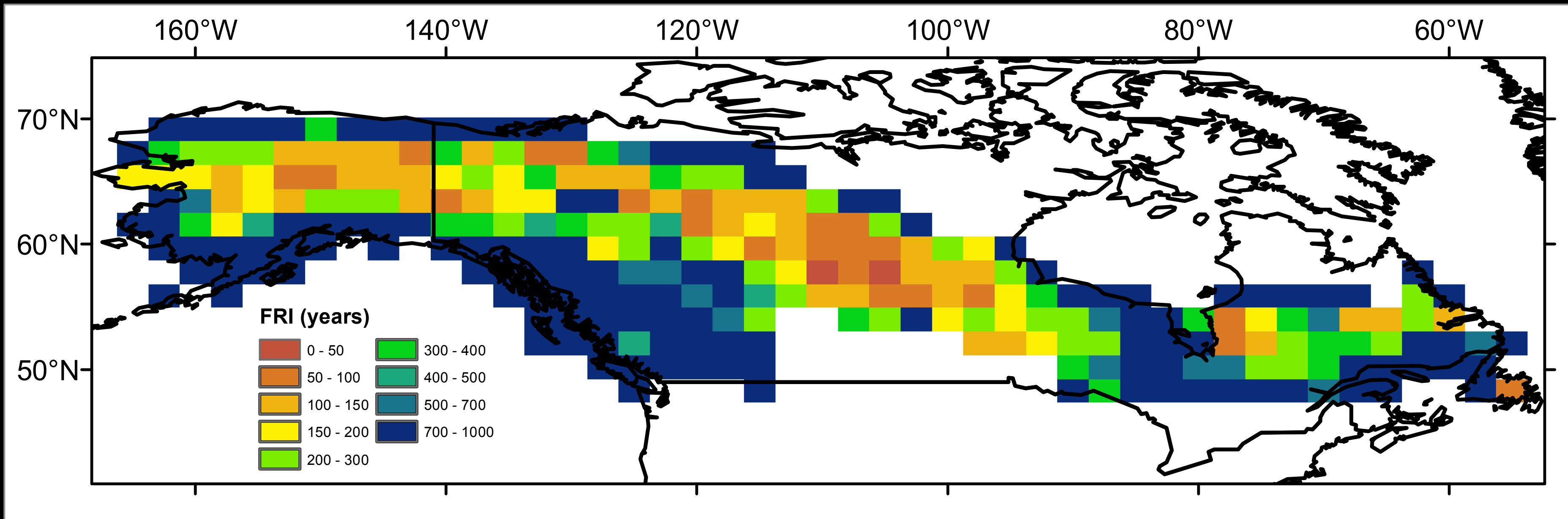

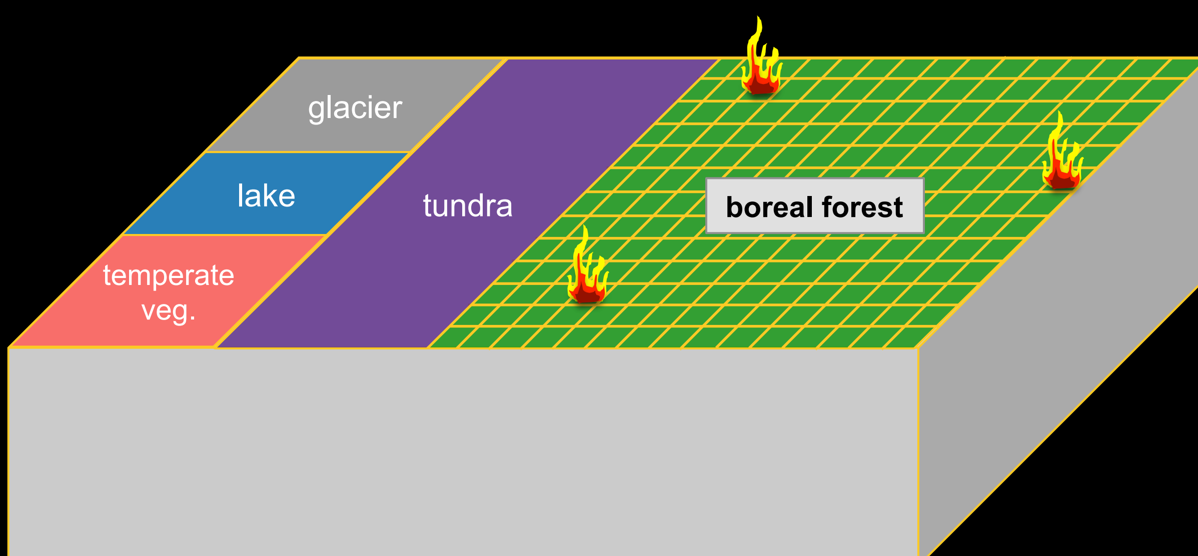

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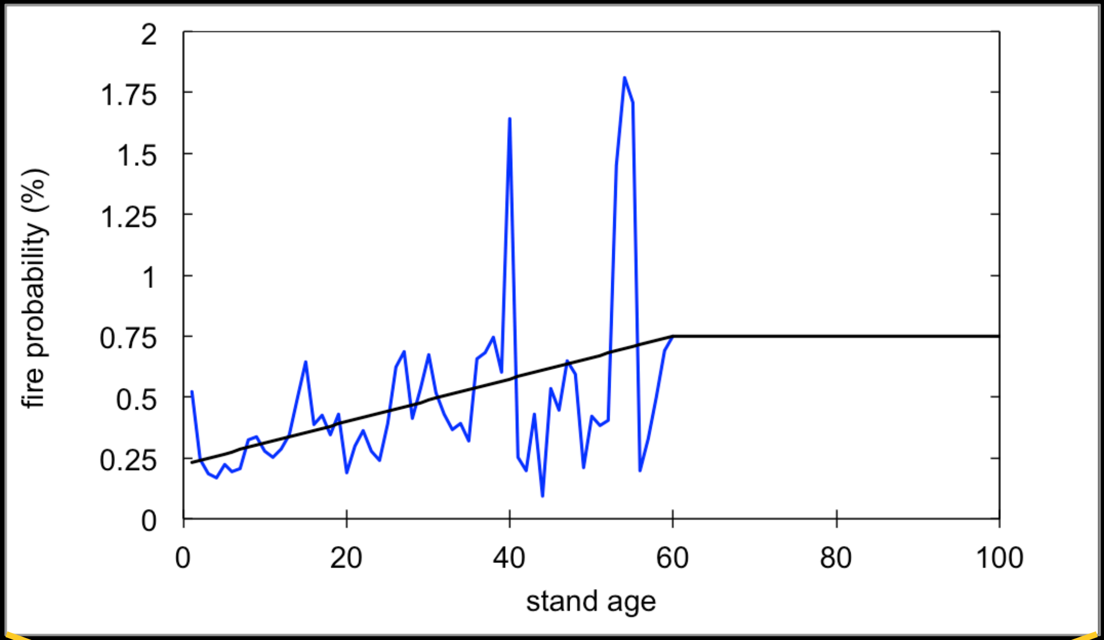

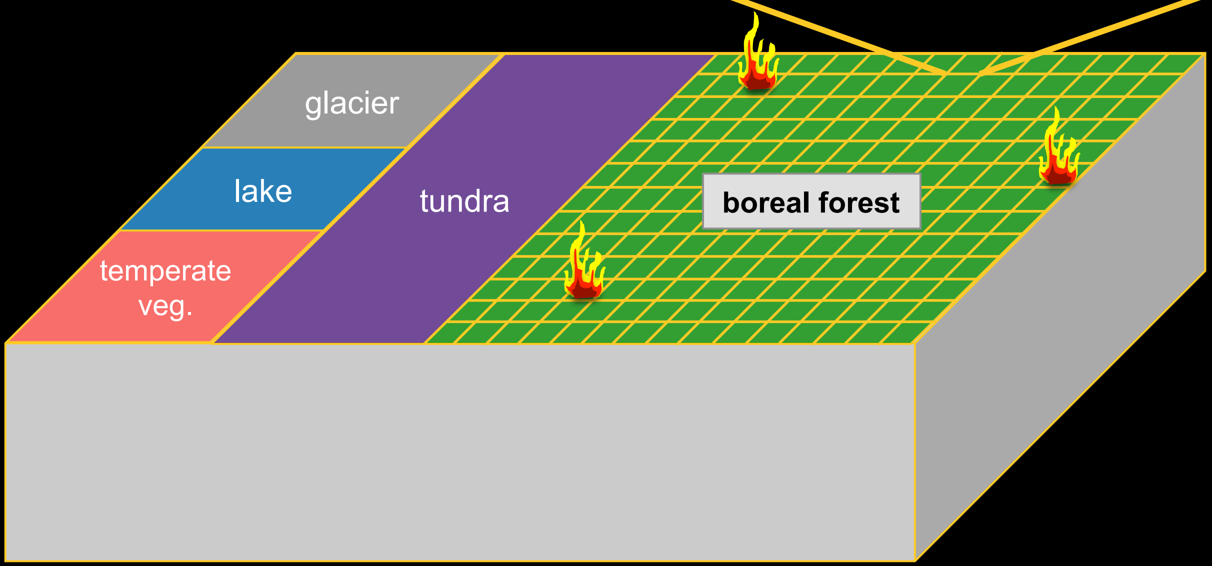

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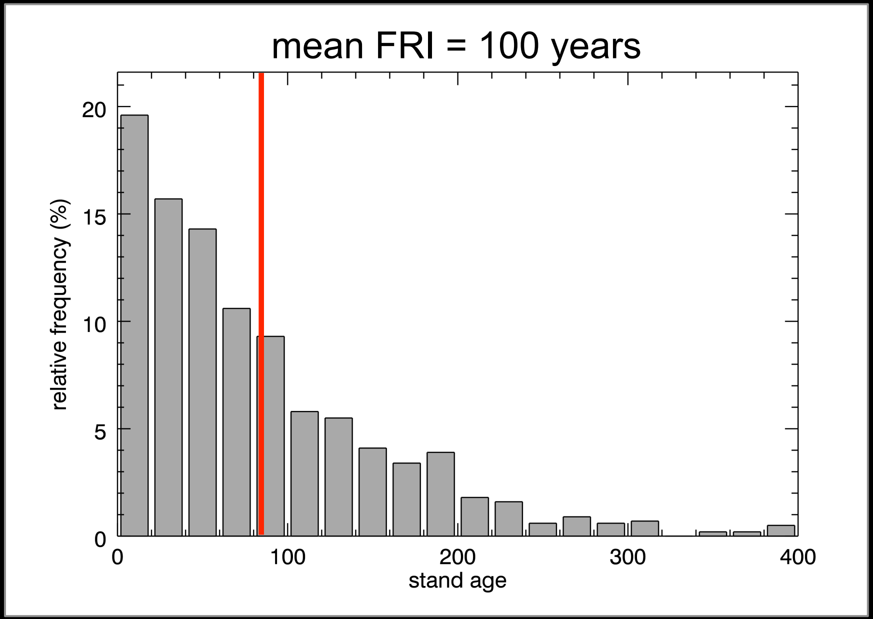

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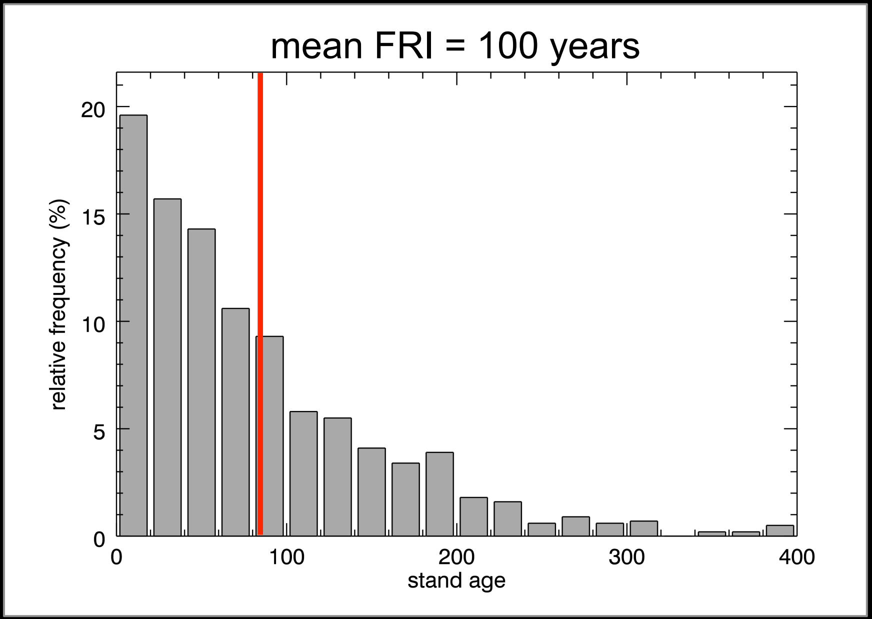

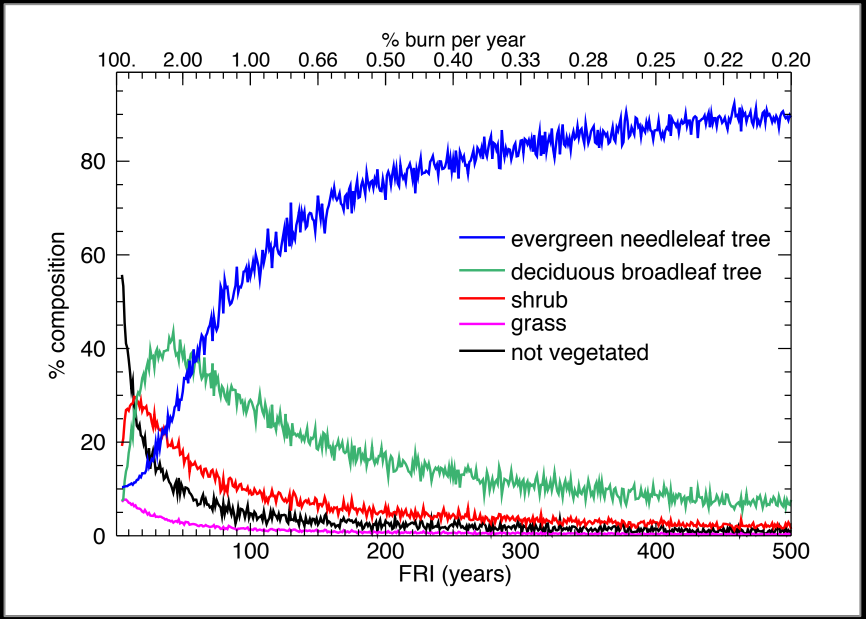

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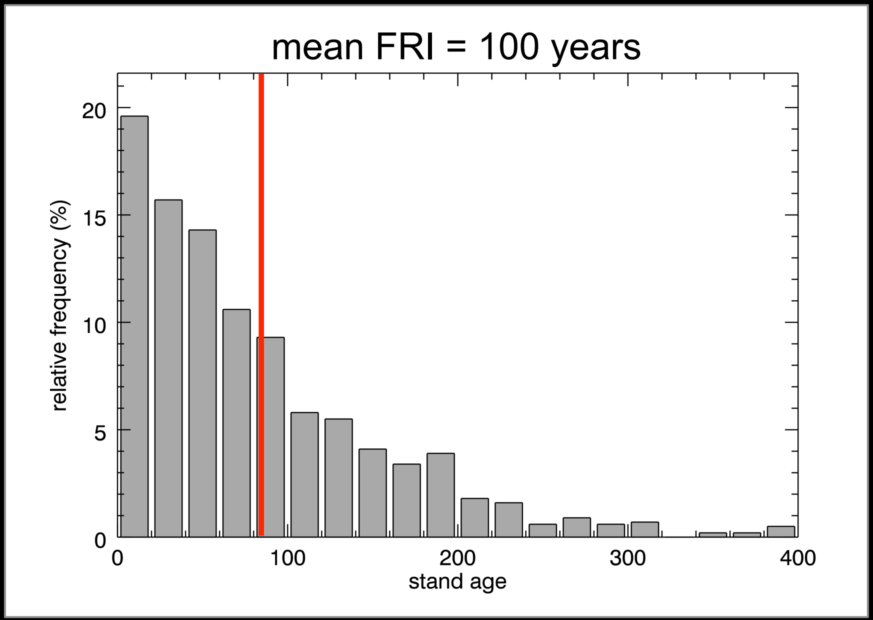
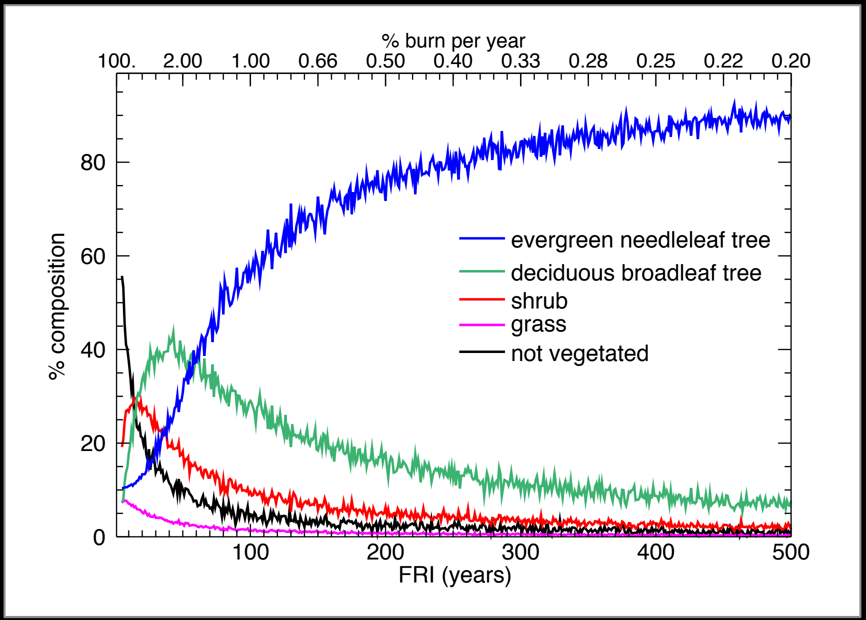
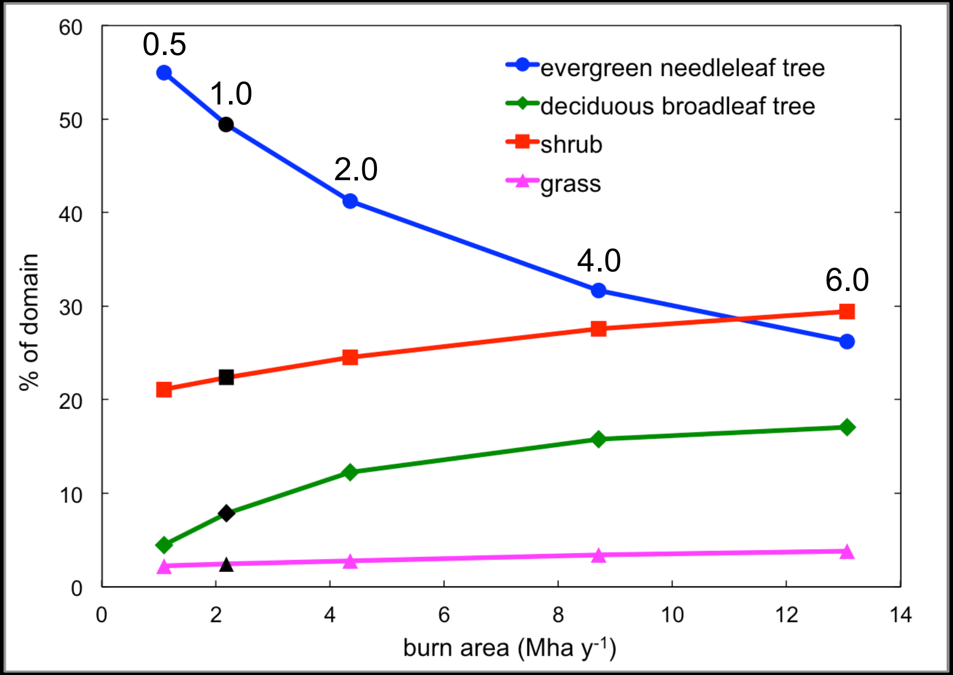
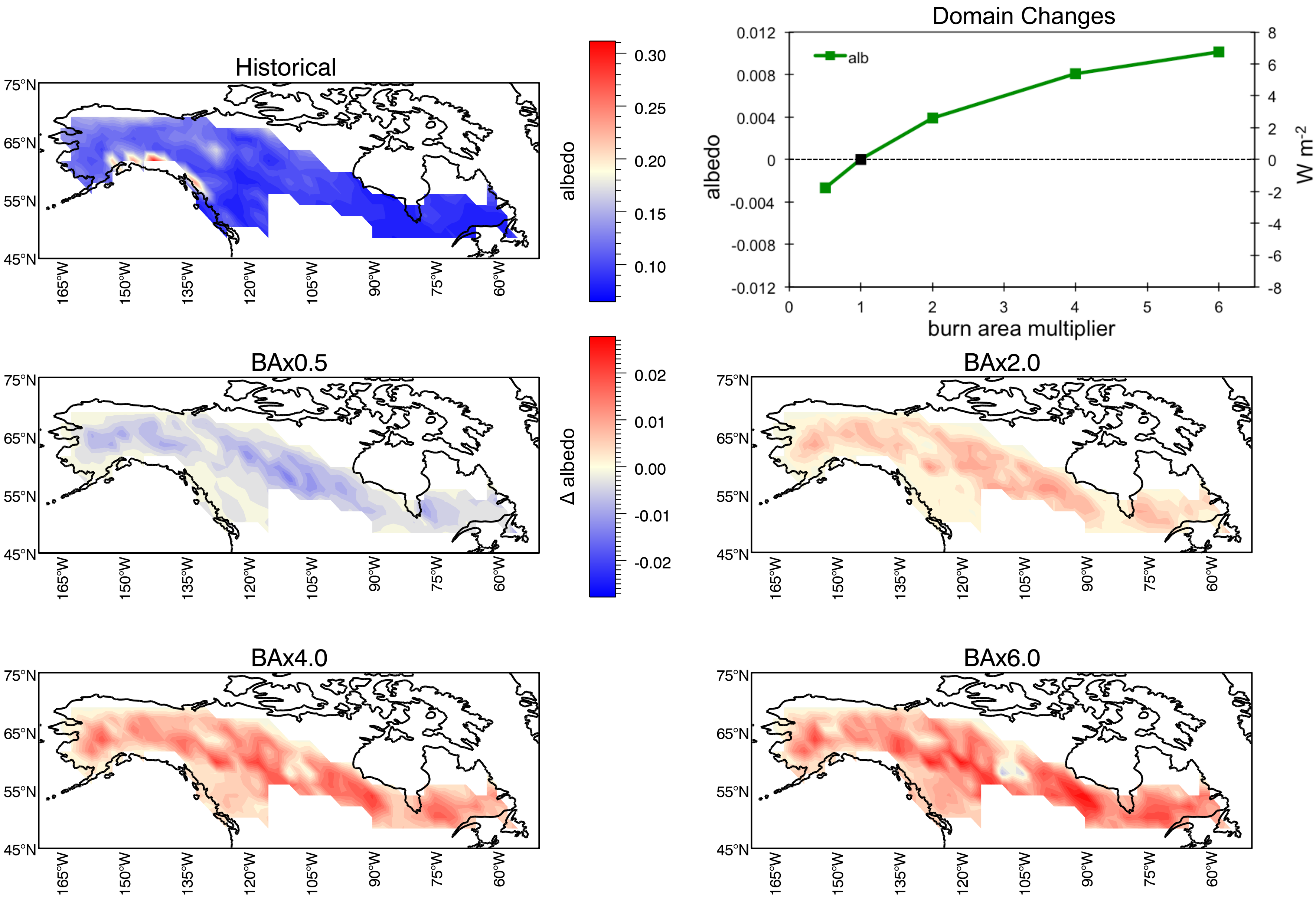






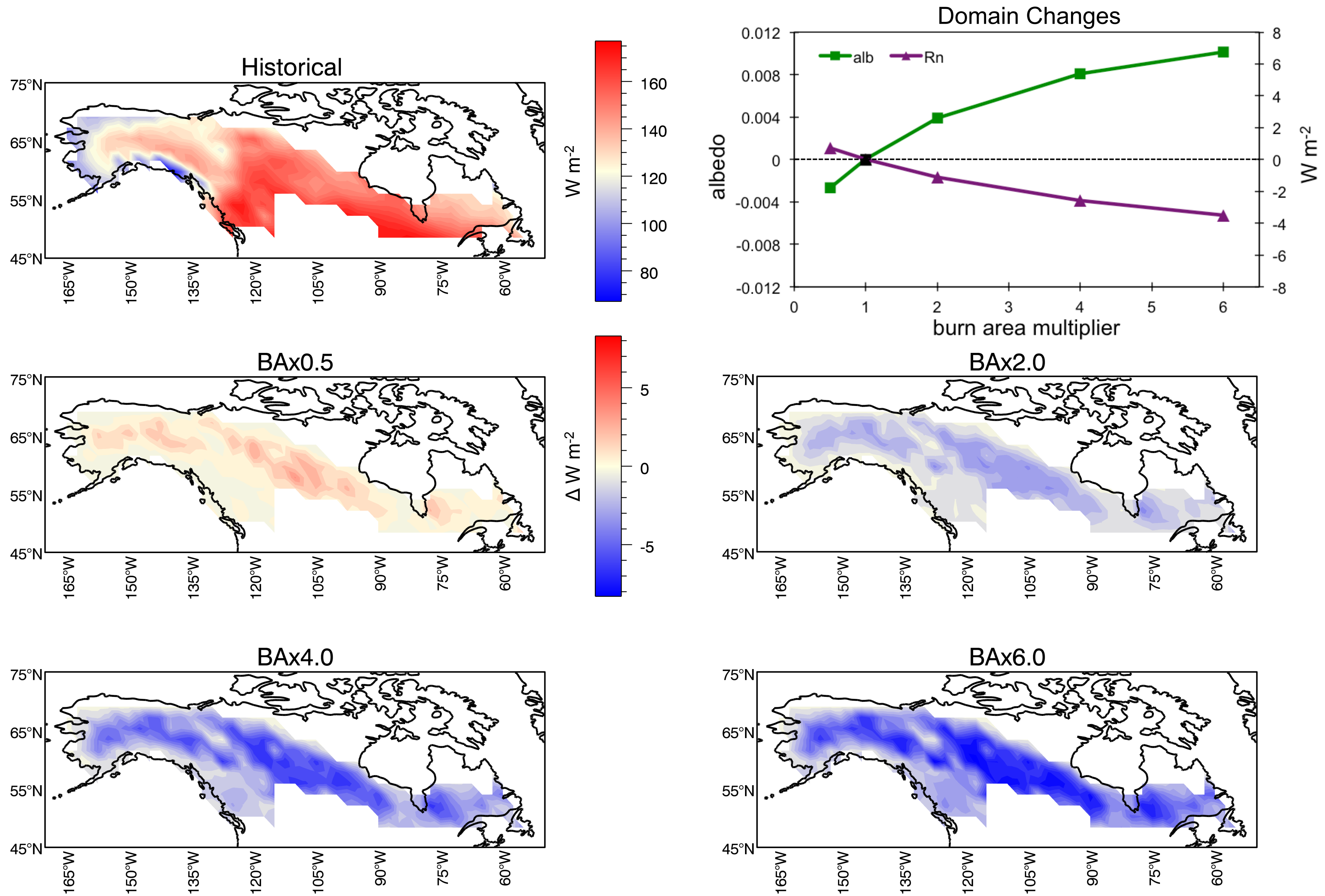
CLM Simulations

summer albedo



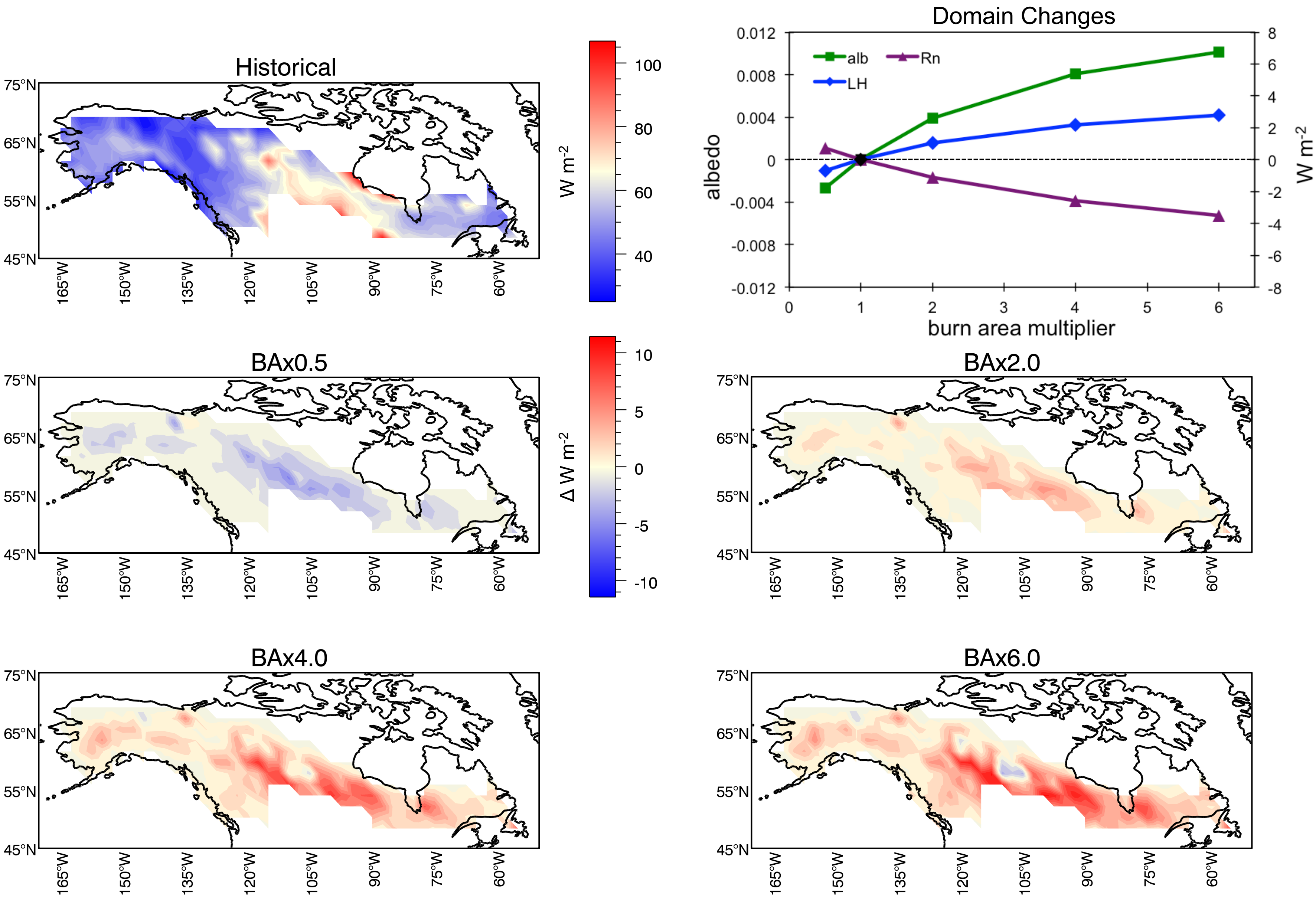
CLM Simulations

summer net radiation



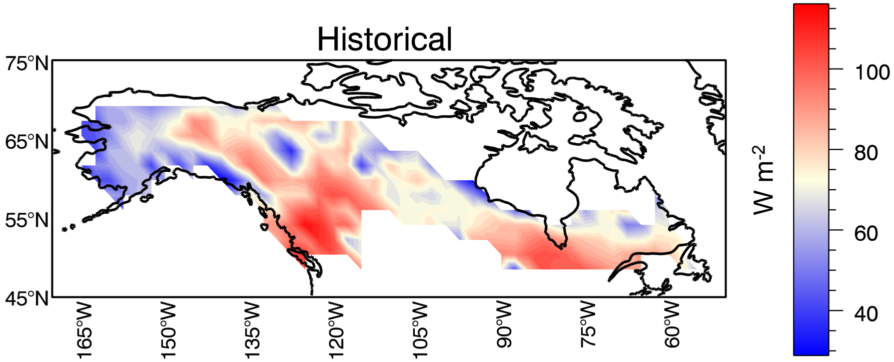
CLM Simulations

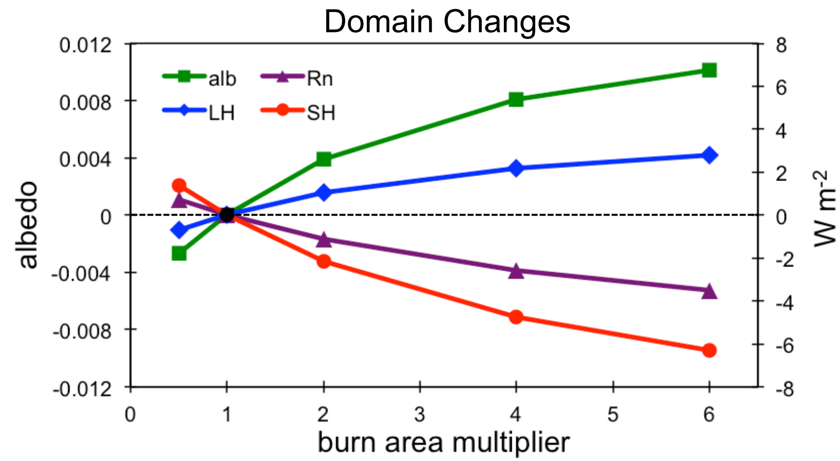
summer latent heat

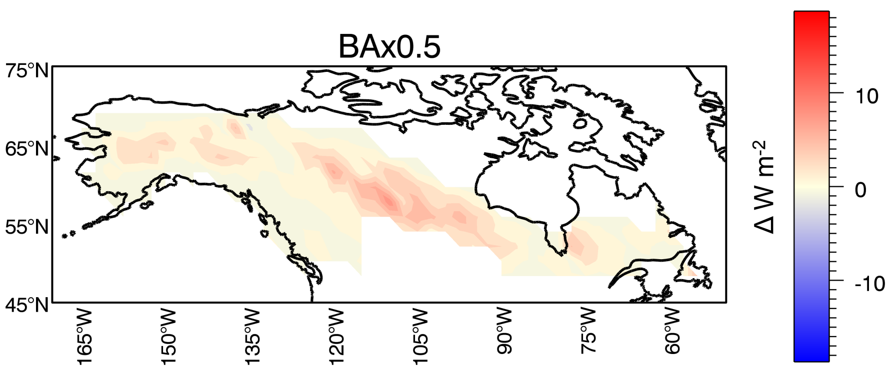


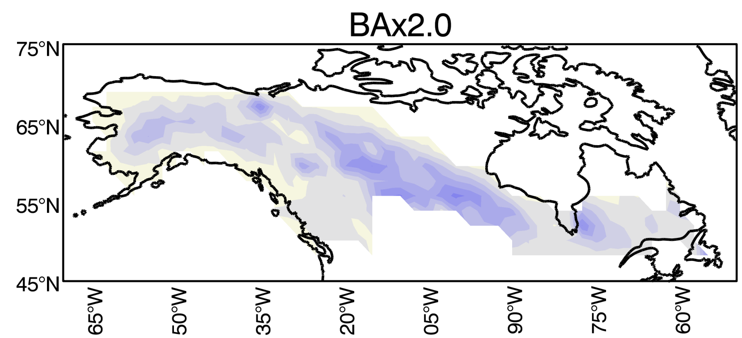
CLM Simulations

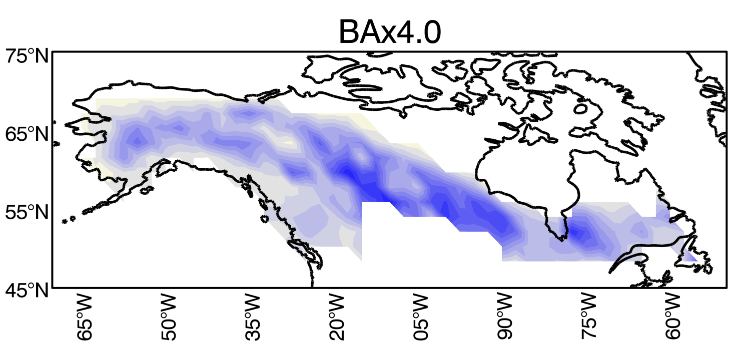
summer sensible heat

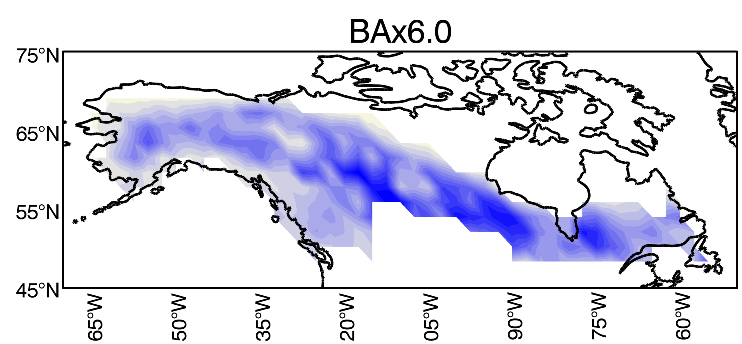






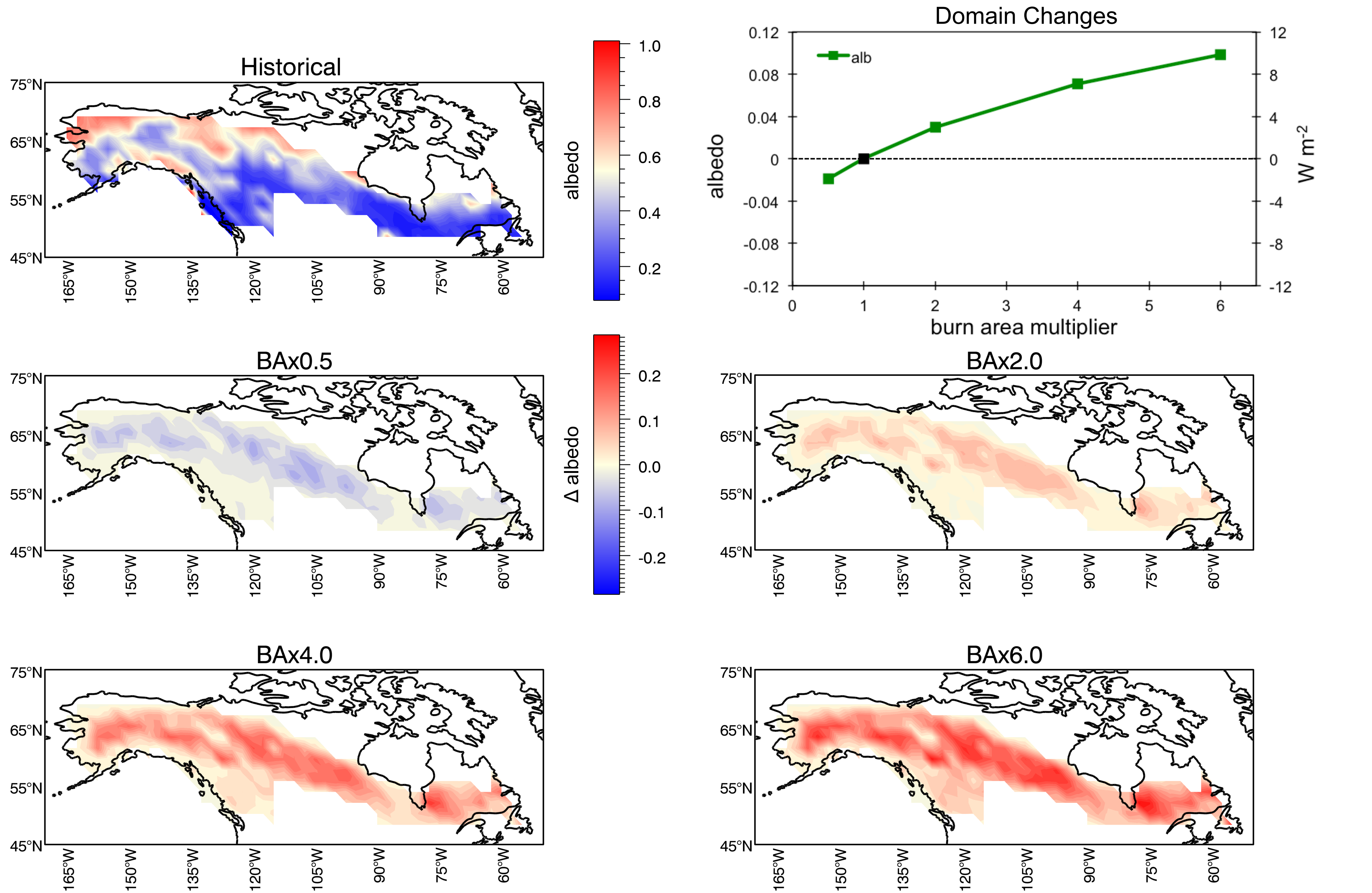






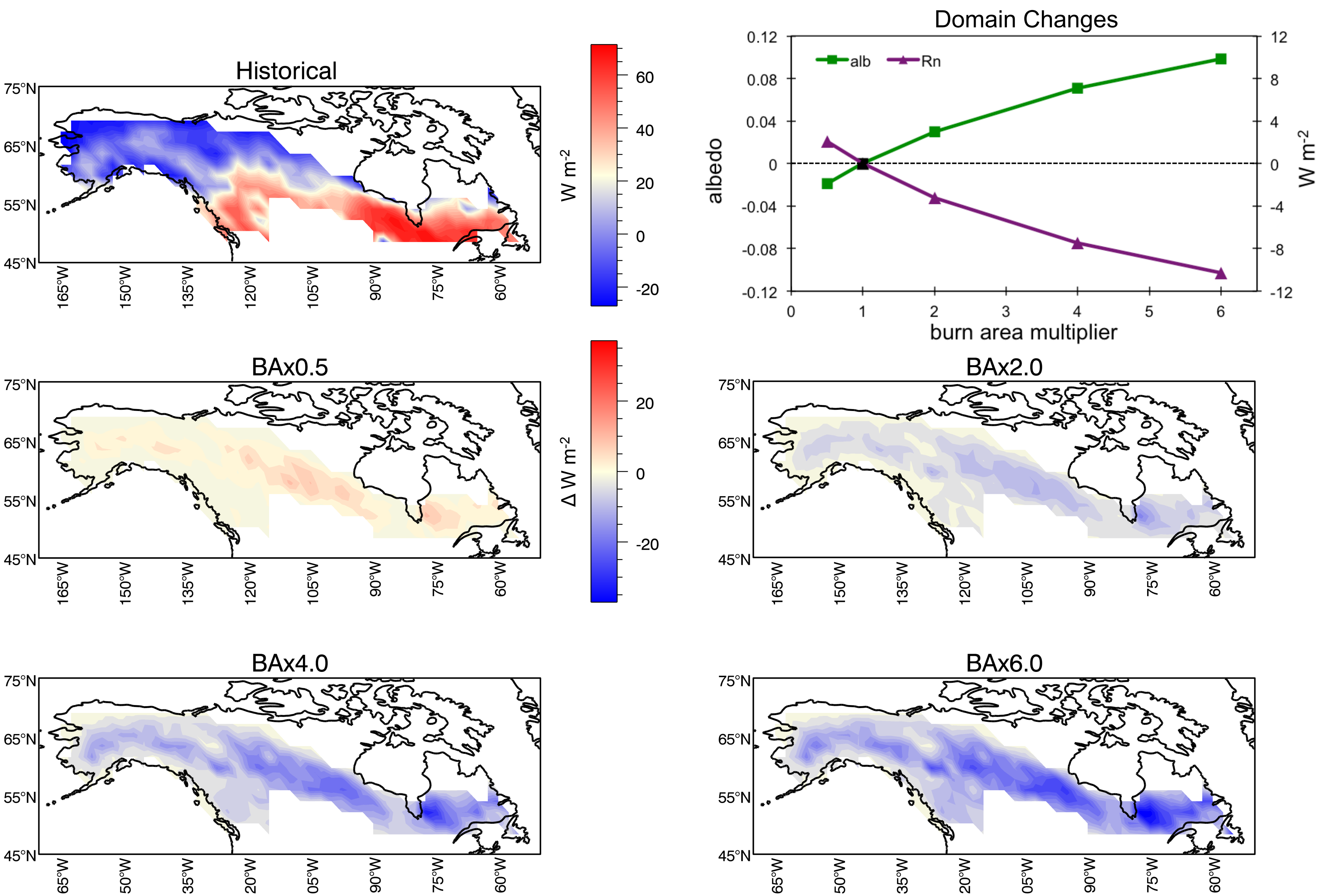
CLM Simulations

spring albedo



CLM Simulations

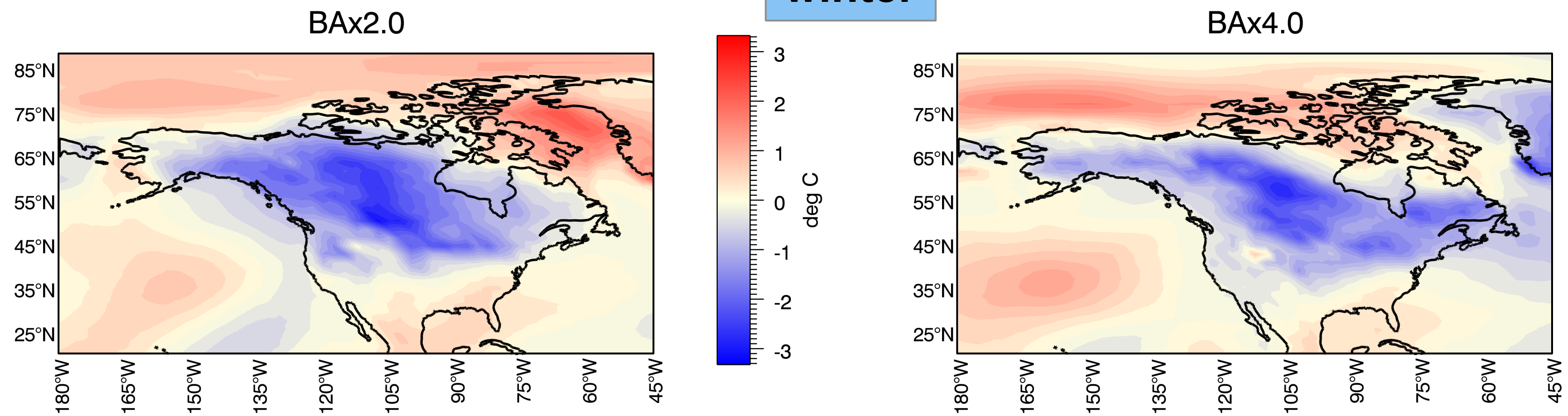
spring net radiation



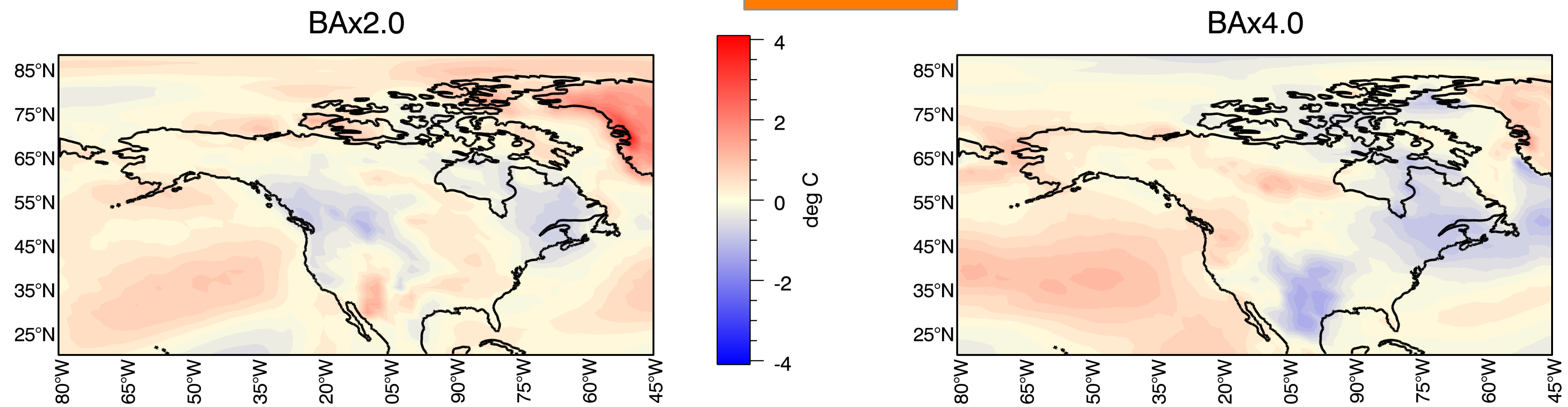
CESM Simulations

surface temperature anomalies

winter

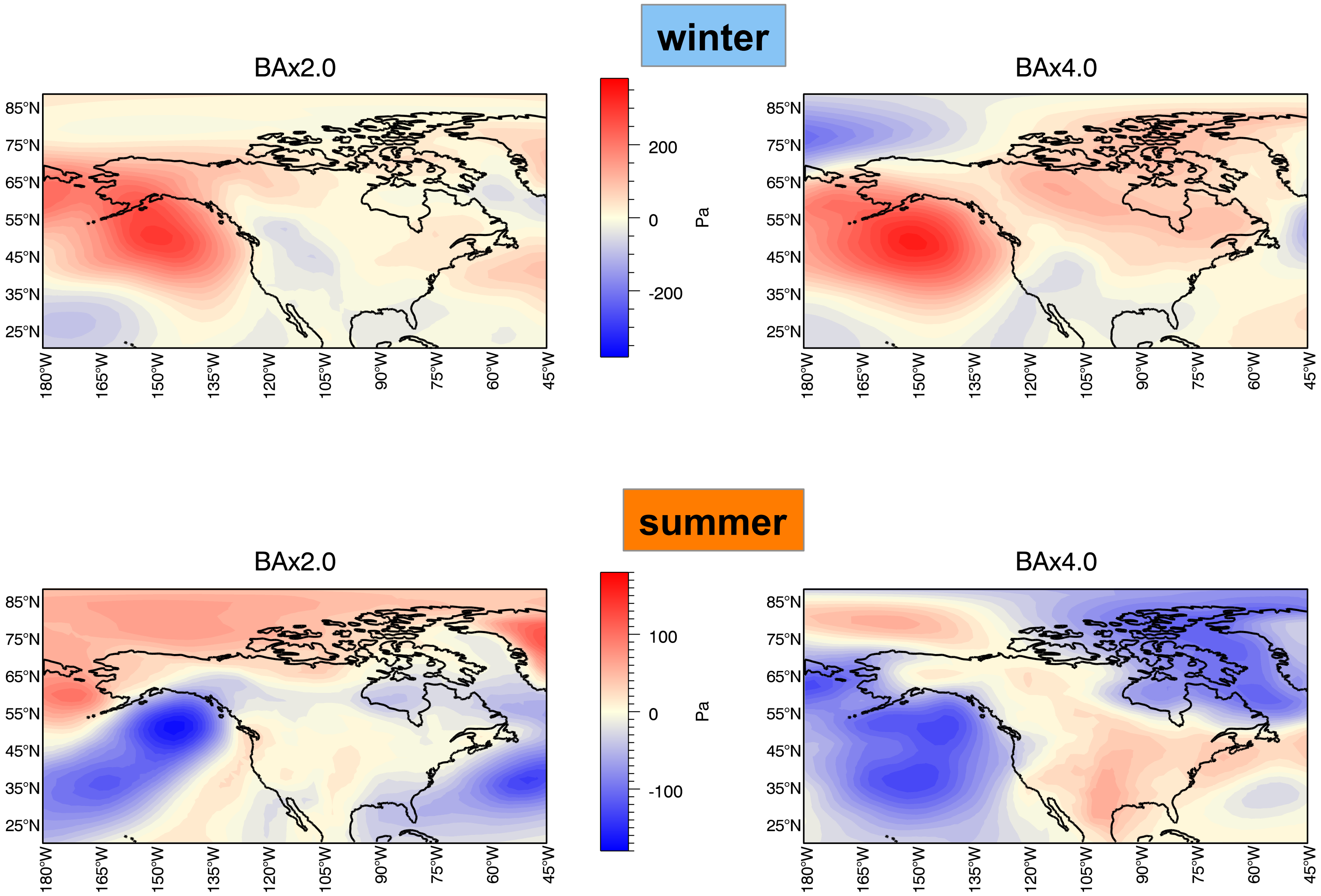


summer



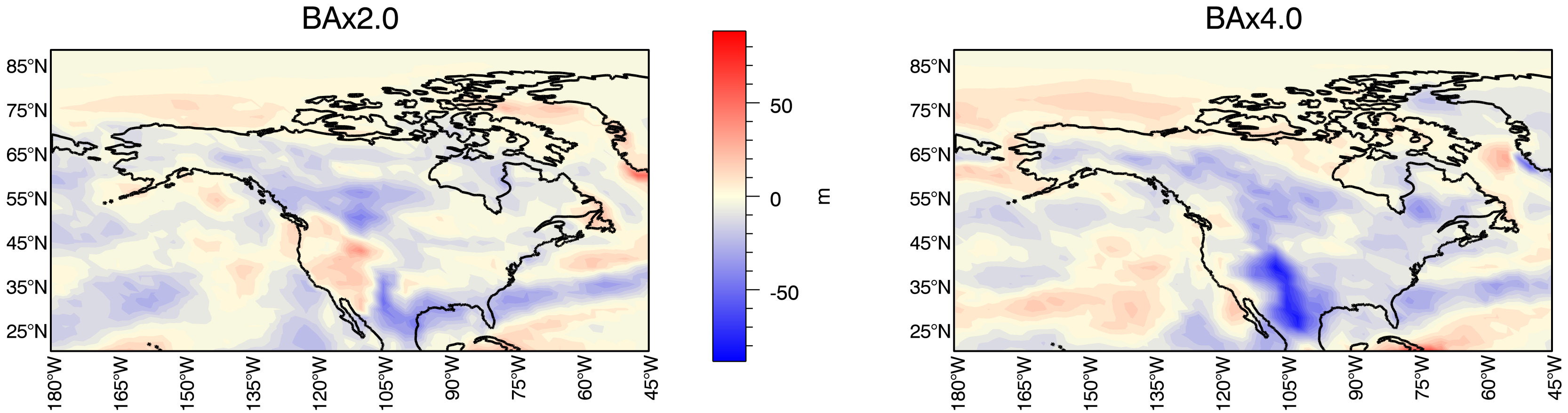
CESM Simulations

surface pressure anomalies



CESM Simulations

boundary layer height anomalies



Conclusions

- used Large Fire databases and MODIS to derive boreal forest cover, succession patterns, burn probabilities, and long-term fire regimes

- with some minor paramaterization changes and the addition of a 'char' PFT, post-fire energy budgets are well-captured in CLM

- increased burning:
  - younger, shorter stands with more deciduous vegetation
  - colder winters
  - modulation of north Pacific pressure systems (?)
  - lowered boundary layer heights

- caveats:
  - prescribed succession and fire
  - succession and burning increases are spatially constant
  - excluded smoke aerosols

- future work:
  - add fire-emitted aerosols, GHGs/carbon balance
  - Eurasian analysis
  - improve dynamic vegetation and fire in boreal systems

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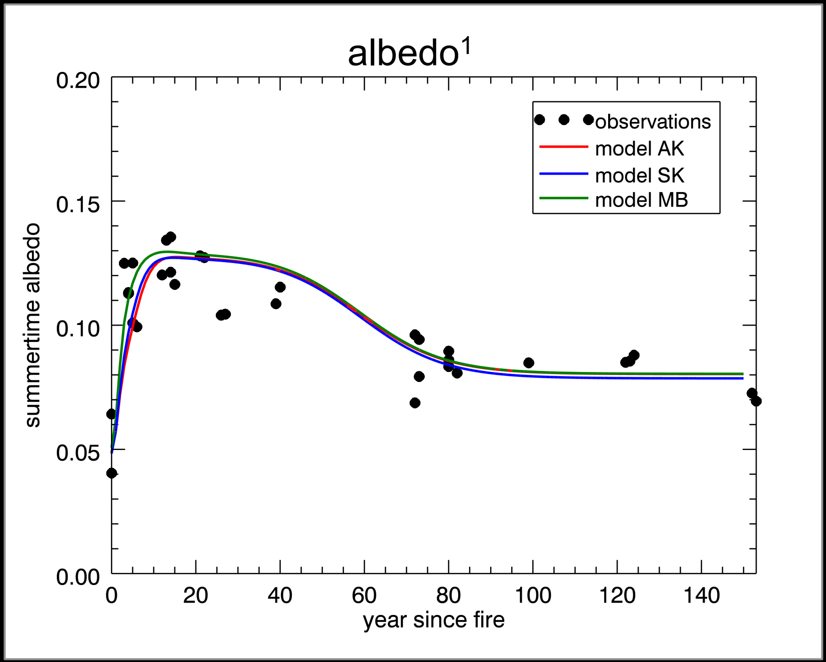
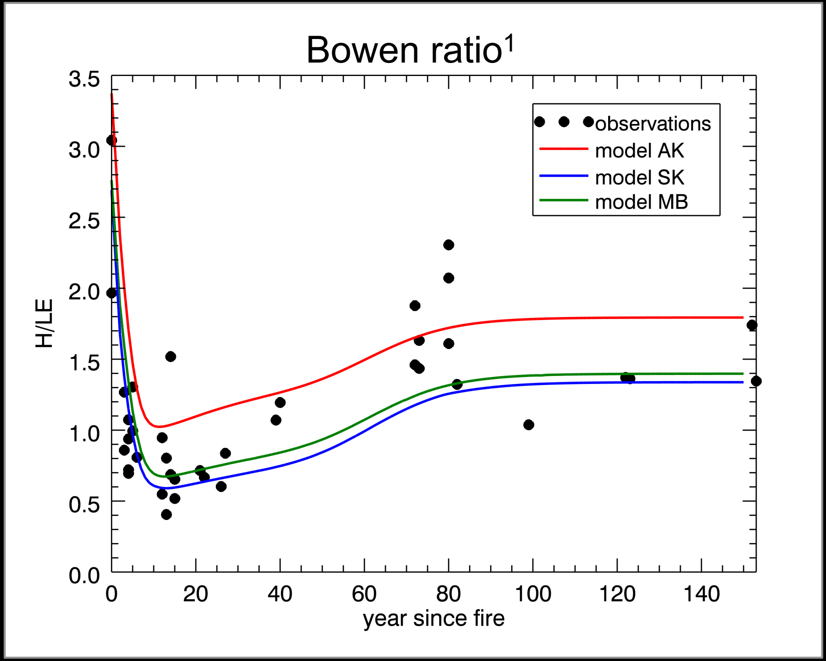
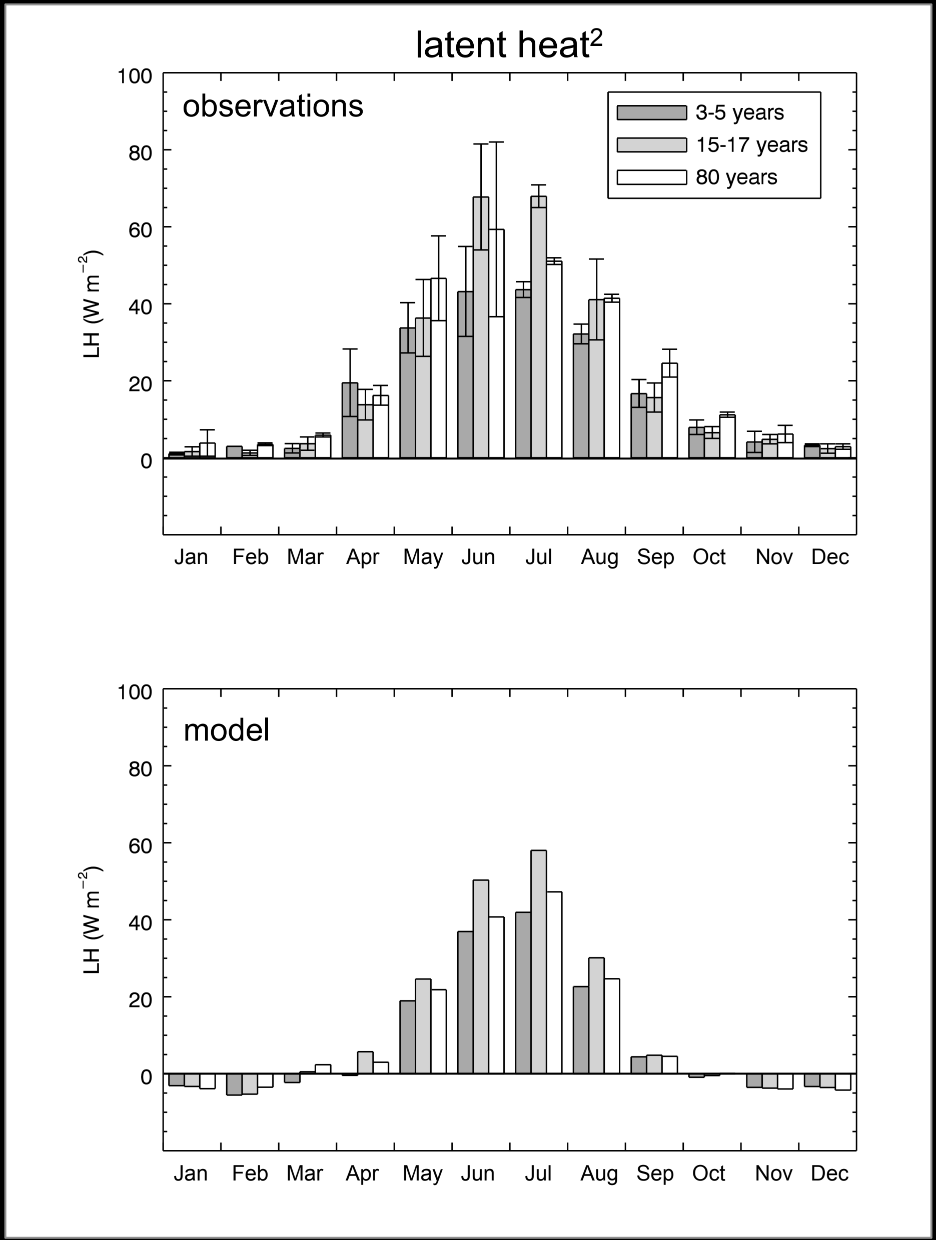
Samuel Levis, Amber Soja and the NCAR ASP program

Validation: summer







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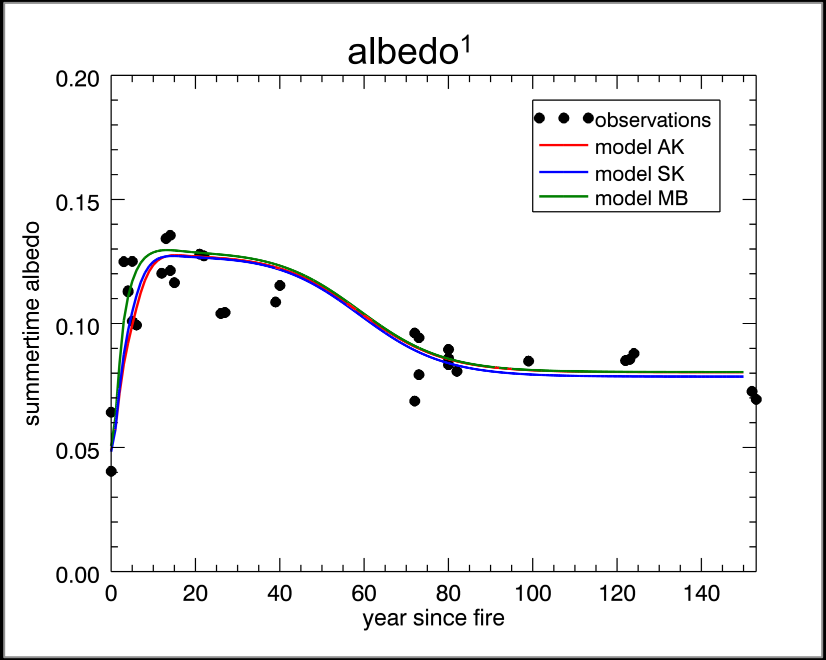
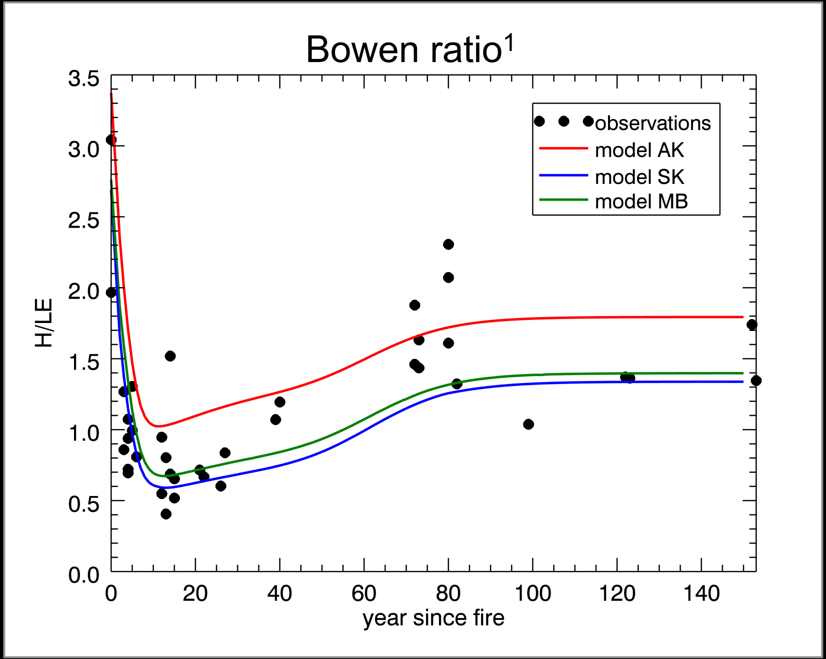
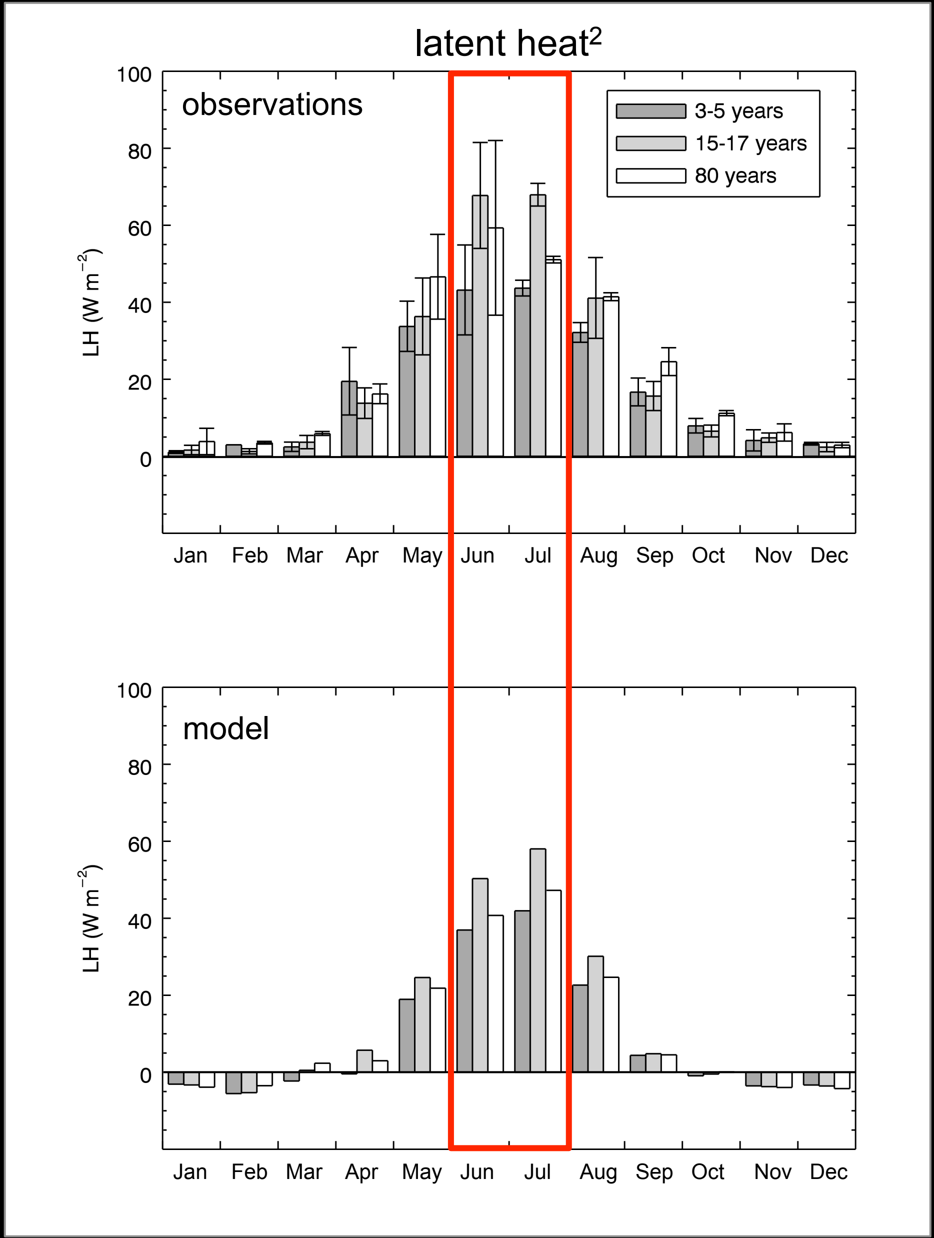
[2]observations from *Liu & Randerson* [2008]

Validation: summer







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[2]observations from *Liu & Randerson* [2008]

Offline Simulations

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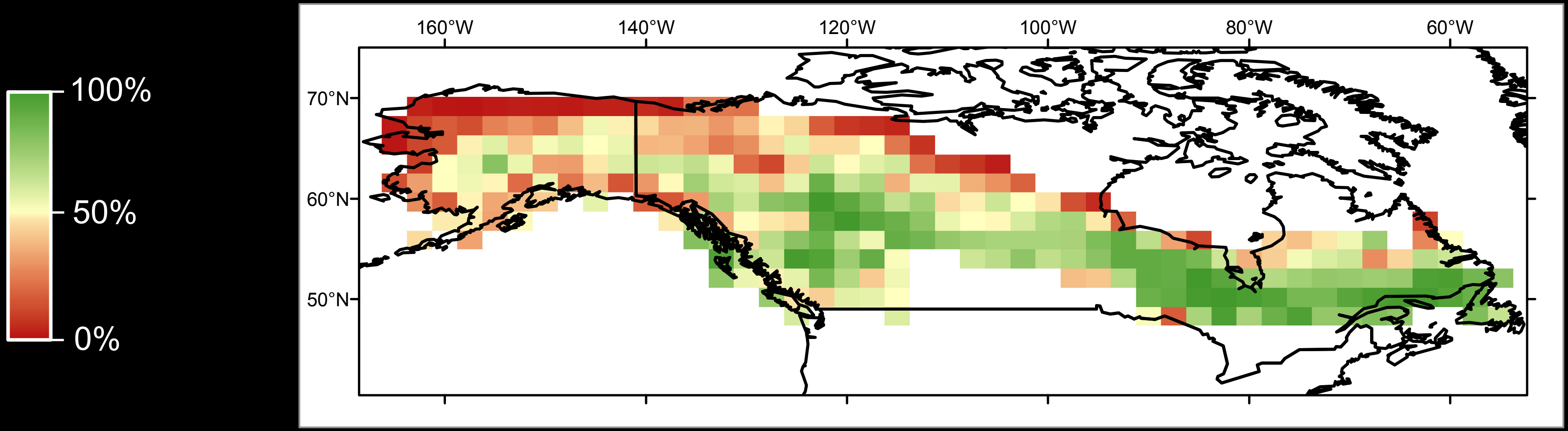
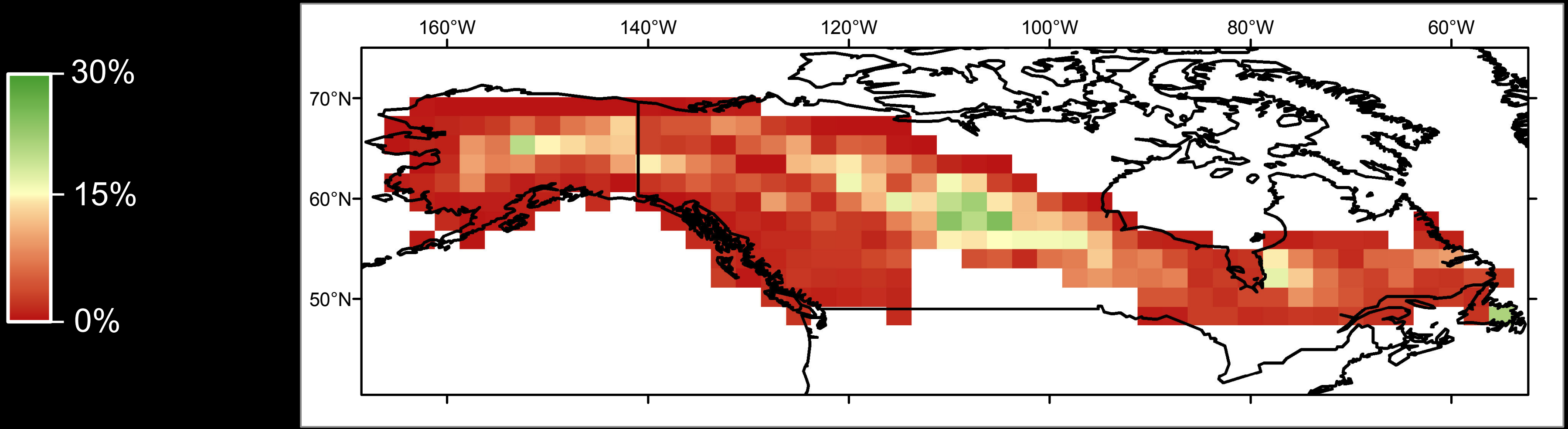
boreal evergreen needleleaf trees



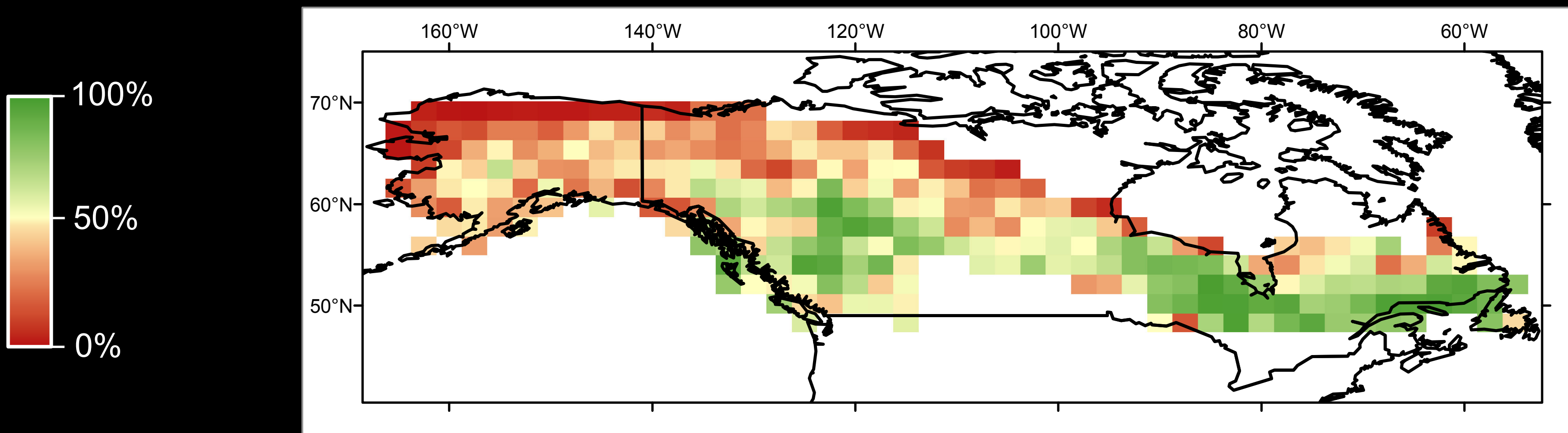
boreal deciduous broadleaf trees



Offline Simulations

historical x 1

boreal evergreen needleleaf trees



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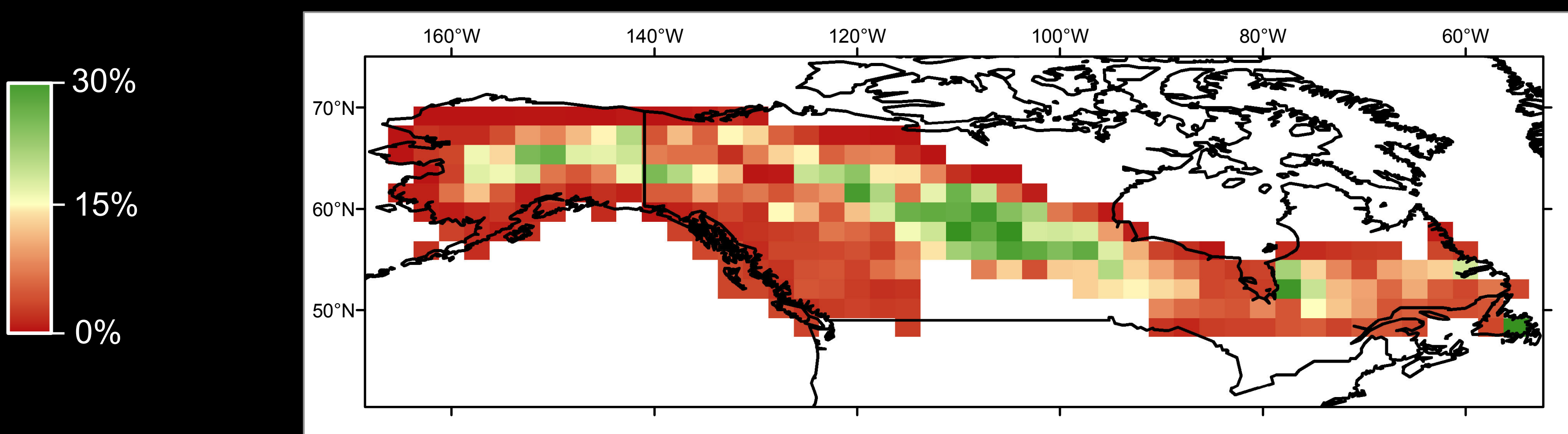
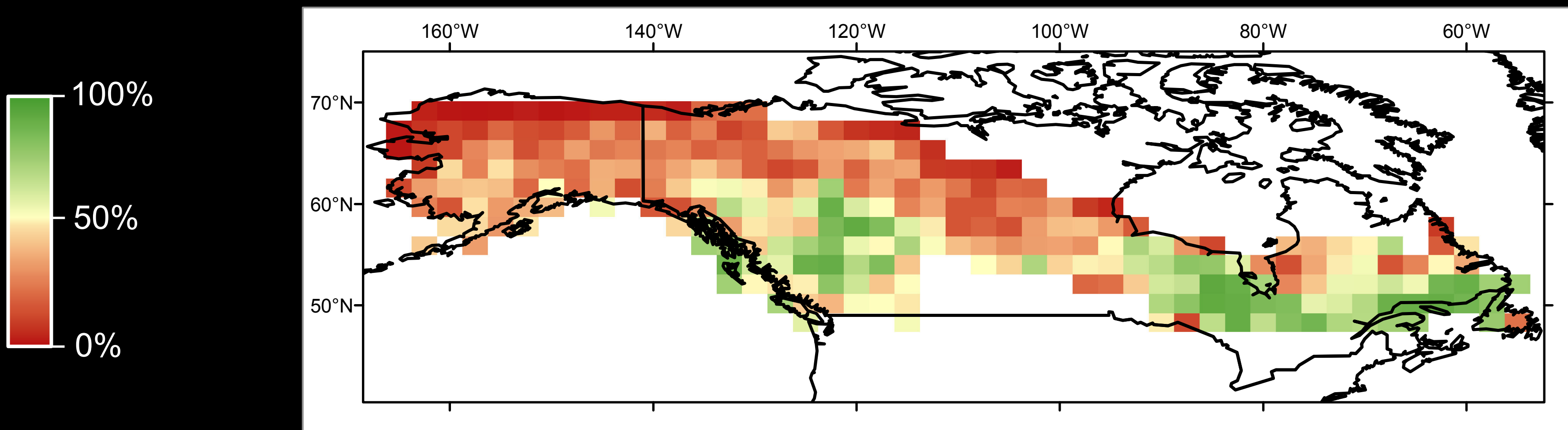


Offline Simulations

historical x 2

boreal evergreen needleleaf trees



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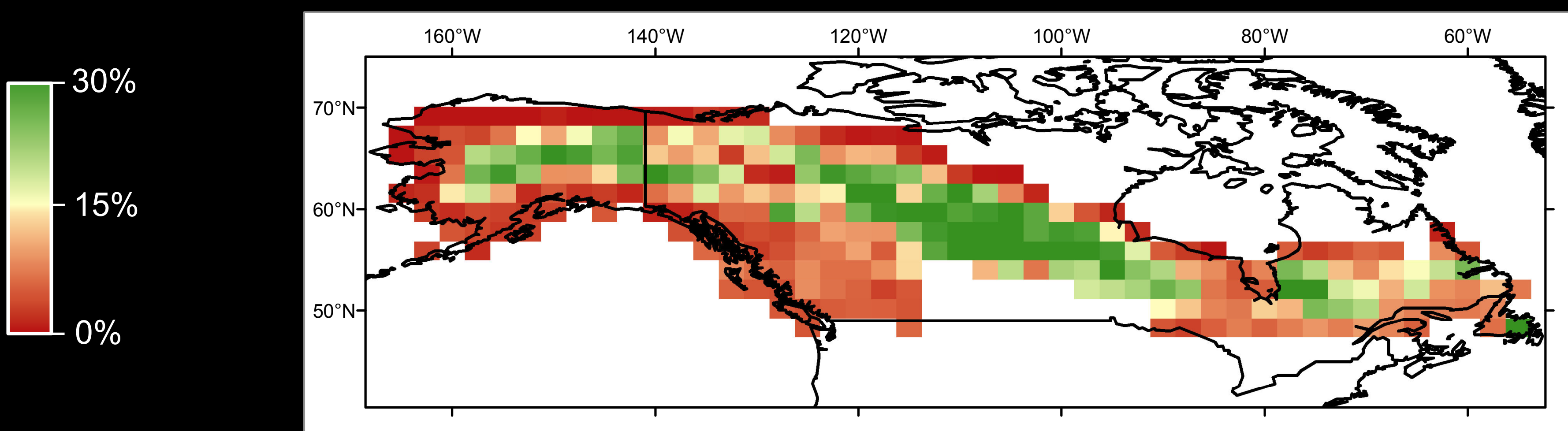
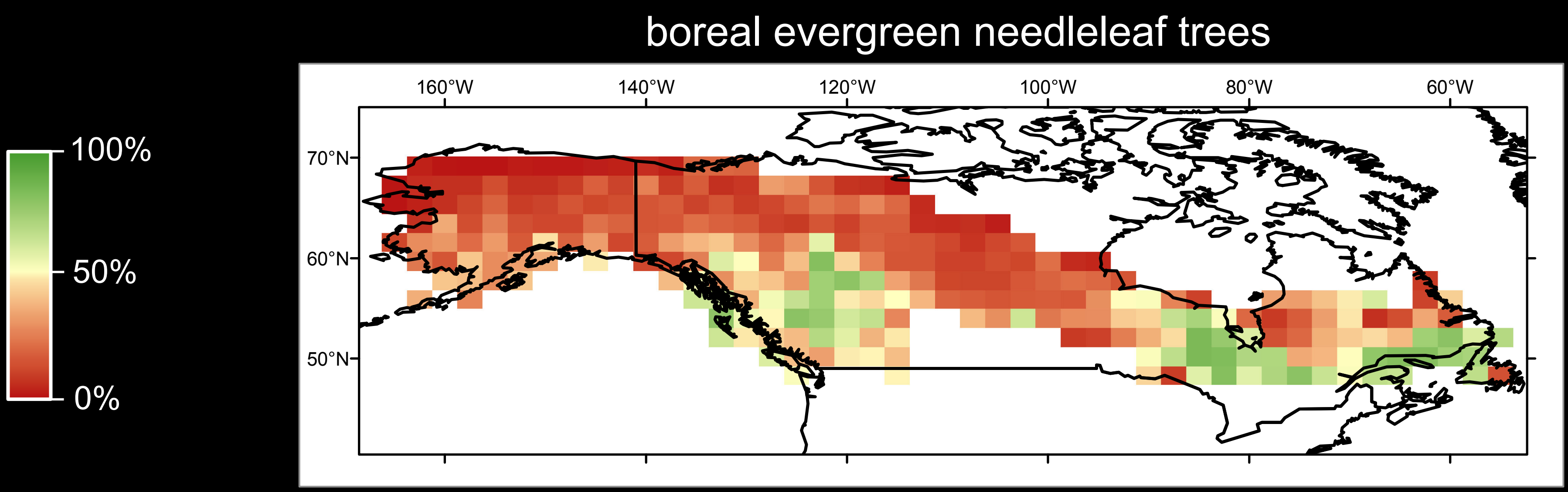
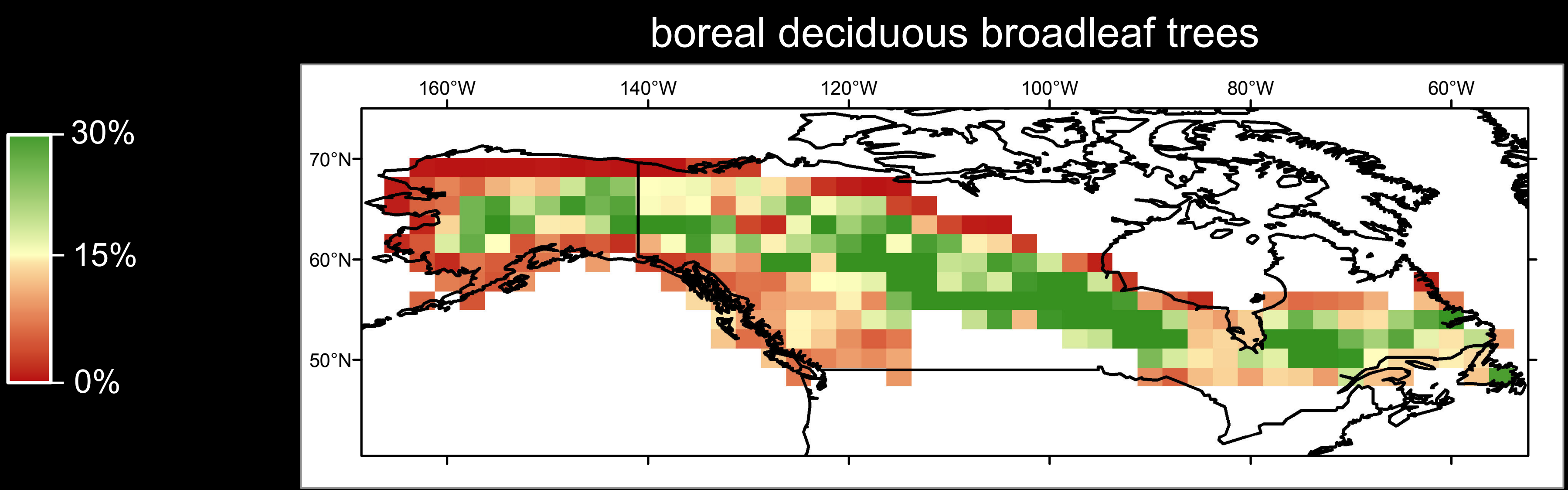


Offline Simulations

historical x 4

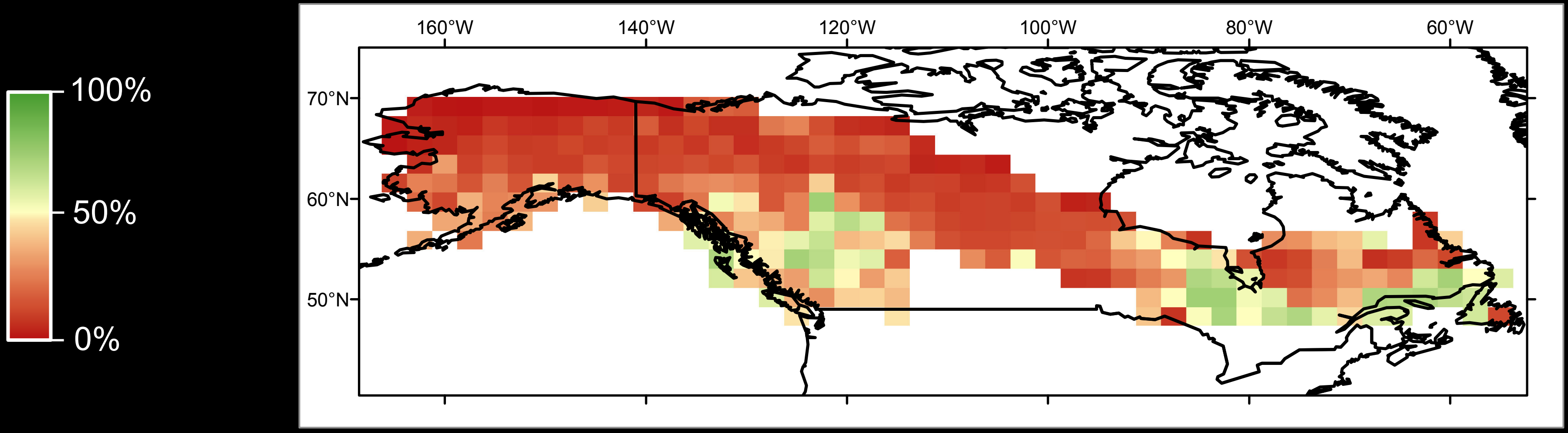




Offline Simulations

historical x 6

boreal evergreen needleleaf trees



boreal deciduous broadleaf trees