Building Capacity in the CLM to Better Model Forest Management

Joshua M. Rady, PhD Student

R. Q. Thomas Lab

Forest Resources and Environmental Conservation

Virginia Tech

Motivation / Problem Description

- Forest management is minimally represented in the CLM.
- Forest management, broadly defined, is pervasive.
  - 52.5% of forests globally have a management plan[1]
- Forests are a major mitigation tool.
  - 25% of emissions reductions in Paris Accord[2]
- Large operational knowledge base
  - Foresters have many tools to alter productivity

1. Global Forest Resources Assessment 2015. FAO, 2016.
2. Grassi et al. Nature Climate Change 7: 220-226, 2017.

What CLM Can and Can't Do

- Can put forest where you want
- Can alter bulk harvest
  - Modify relevant input files

- Can't isolate treatments to specific PFTs
  - Fertilize one species, you fertilize them all
- Can't harvest at species (PFT) level
  - Harvest occurs linearly based on total harvest and PFT weight / fractional coverage.
- Can't harvest realistic rotations
  - Forests harvested with pruning shears

Goals

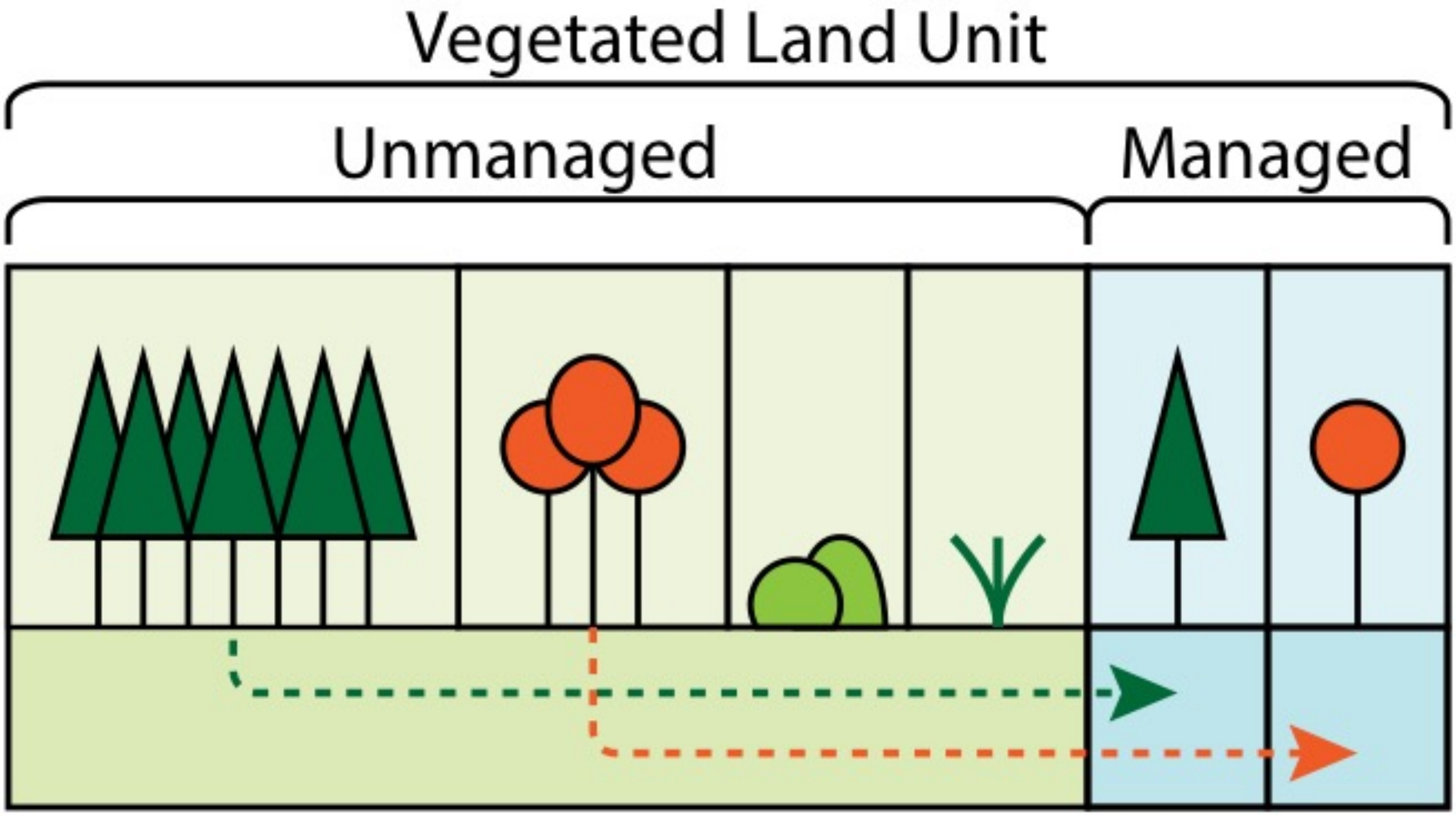
Ultimately:

- Explore climate impacts of forest management.

Currently (*First Steps*):

- Column Mod:
  - Isolate individual PFTs on their own columns.
- Preferential Harvest Mod:
  - Make it possible to harvest from select PFTs first.

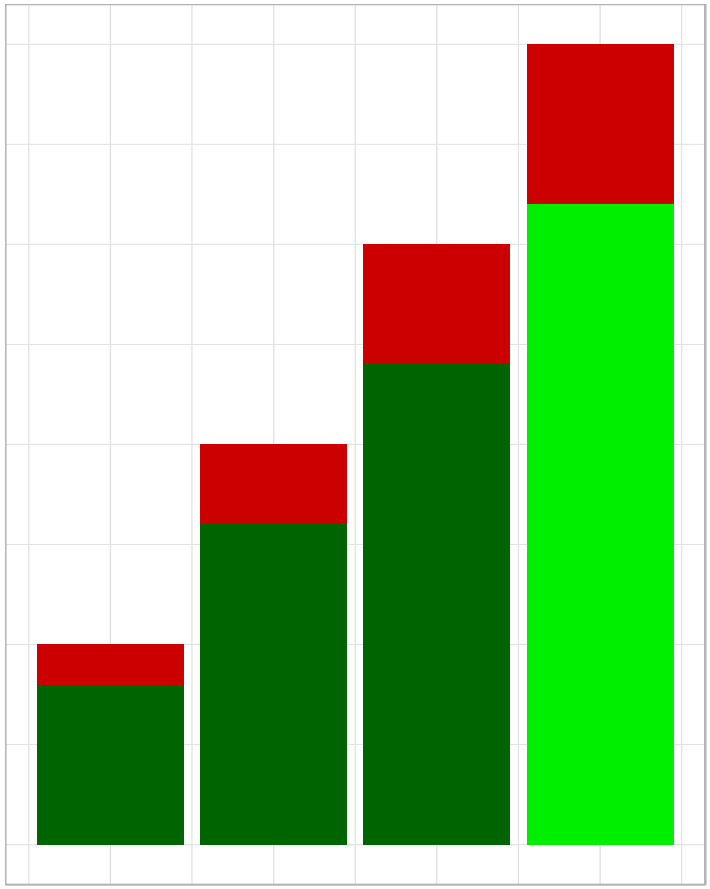
Technical Modifications: PFT Stucture



Technical Modifications: Isolated PFT Columns

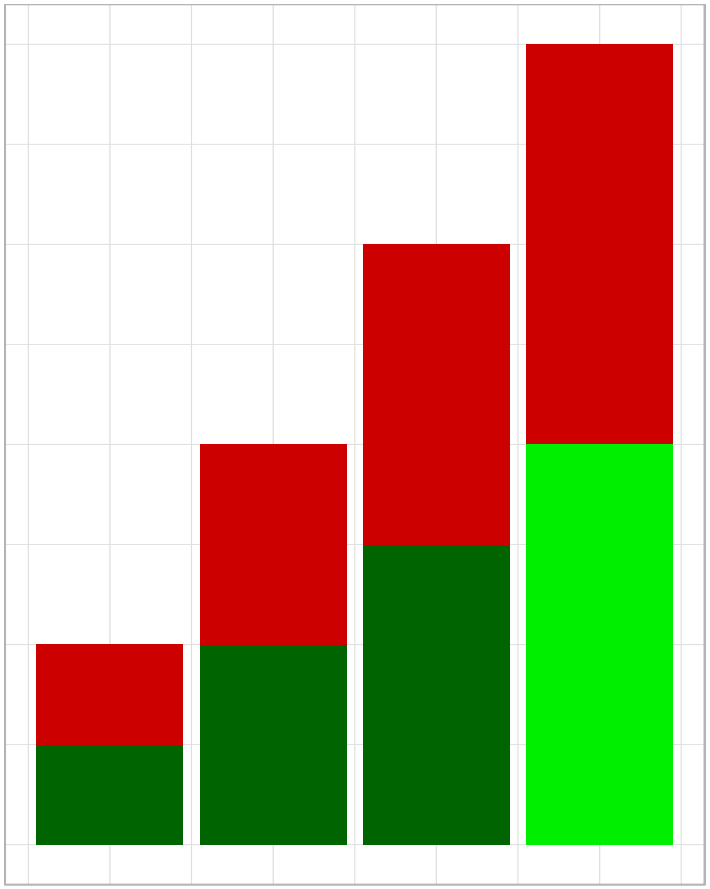
- Modify Sub-grid Data Structure
- PFT Logic:
  - Made the PFT conditionals consistent through the code
  - Alter conditionals for new Independent Column PFTs
- PFT Assumptions in Code
  - Remove assumption that vegetated PFTs share a column
  - Add code to give the new PFTs their own column
- Modify Existing Input Files
  - Copy temperate needle-leaf in PFT parameter file
  - Land Surface, Land Use Time Series, Megan

Technical Modifications: Harvest



:51:12 AM MST

Technical Modifications: Harvest



:51:13 AM MST

Experimental Questions

- Did we break the model?
  - Yes, many times
- Identify changes due to modifications in the model structure
- Are these changes manageable?
  - Are they small compared to anticipated effects?
  - Are there ways to compensate of reduce side effects?

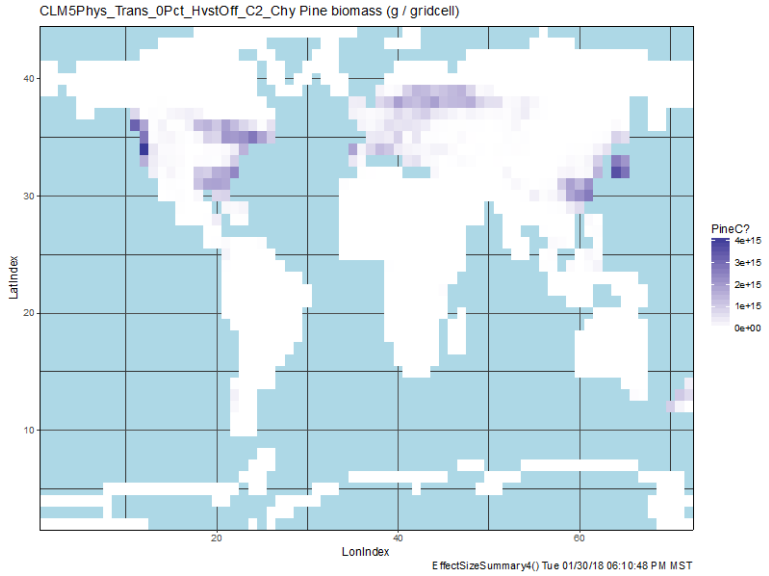
Experimental Design

- CLM5 (recent tag r247)
- 4 x 5 Degree Simulations
- Offline Mode, not coupled to atmosphere
- CRU-NCEP Forcing
- Parallel Spin-ups:
  - 1 spin up for 0%
  - 1 spin up for 100%
- 4 Transient Runs 1850 -2010:
  - Control, column mod, harvest mod, both togeather
- PFT level history file output
- Analyzed effects on Vegetated Land Unit

Results: Subtle at First Glance

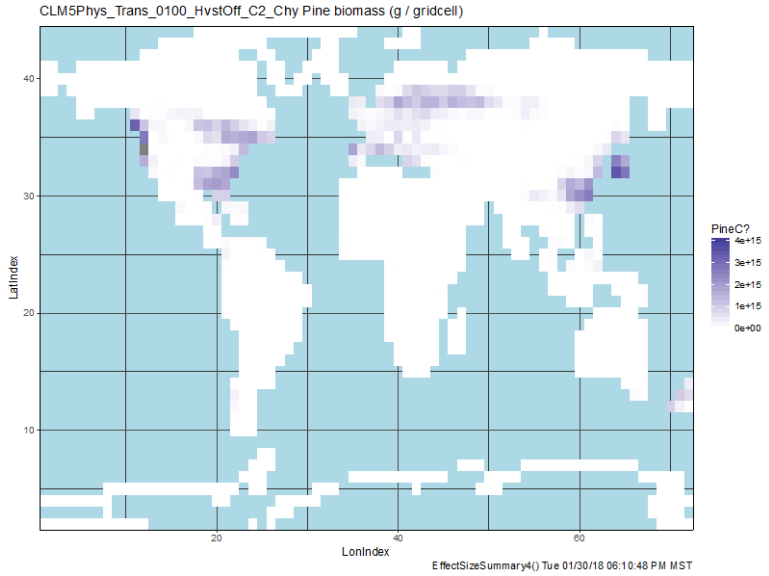
- Data set are the same
- Historical period
- No extreme scenarios

3181 Pg Total Eco C

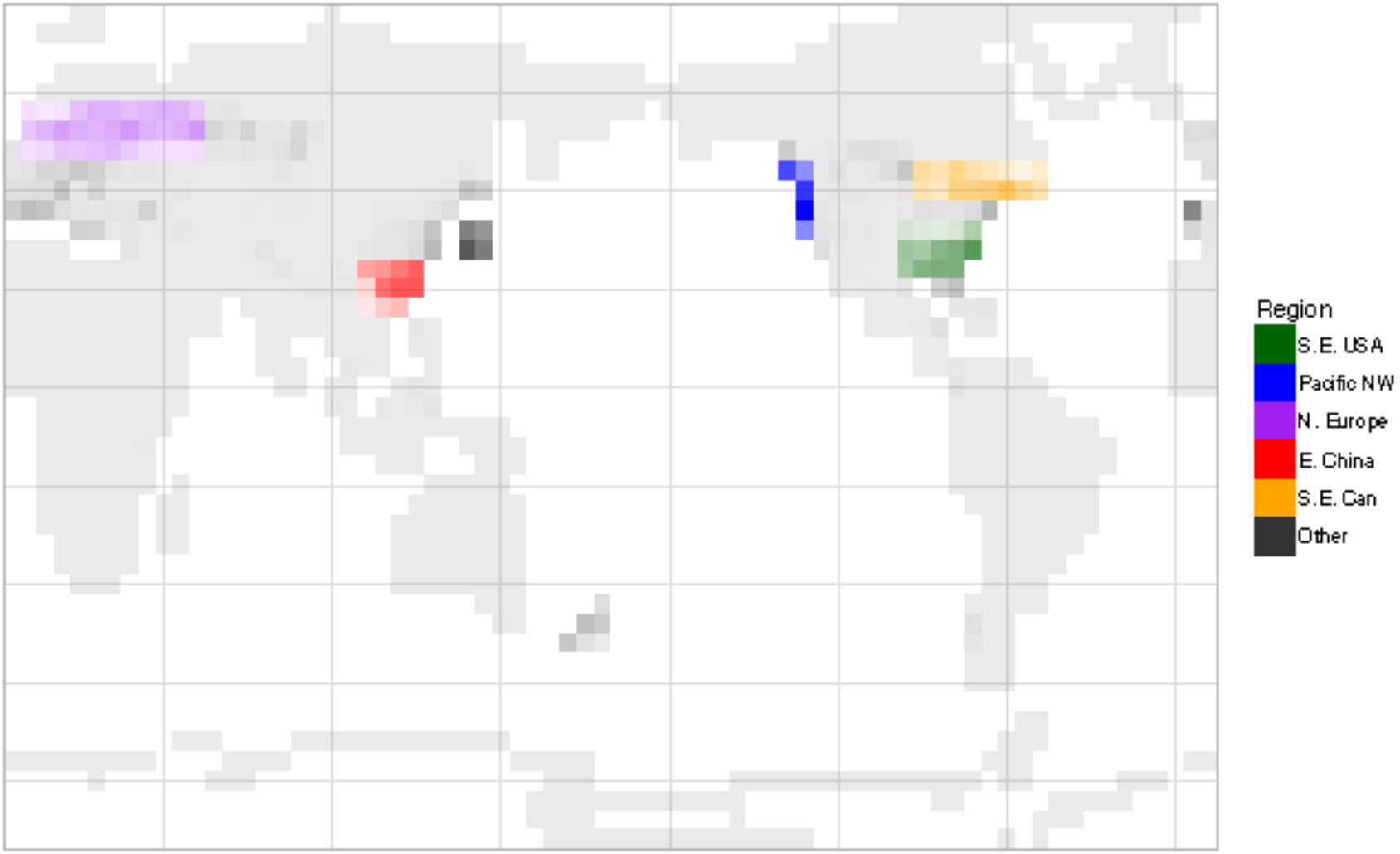


- What did we expect?
- Isn't no change good?
- Pine isn't everywhere.

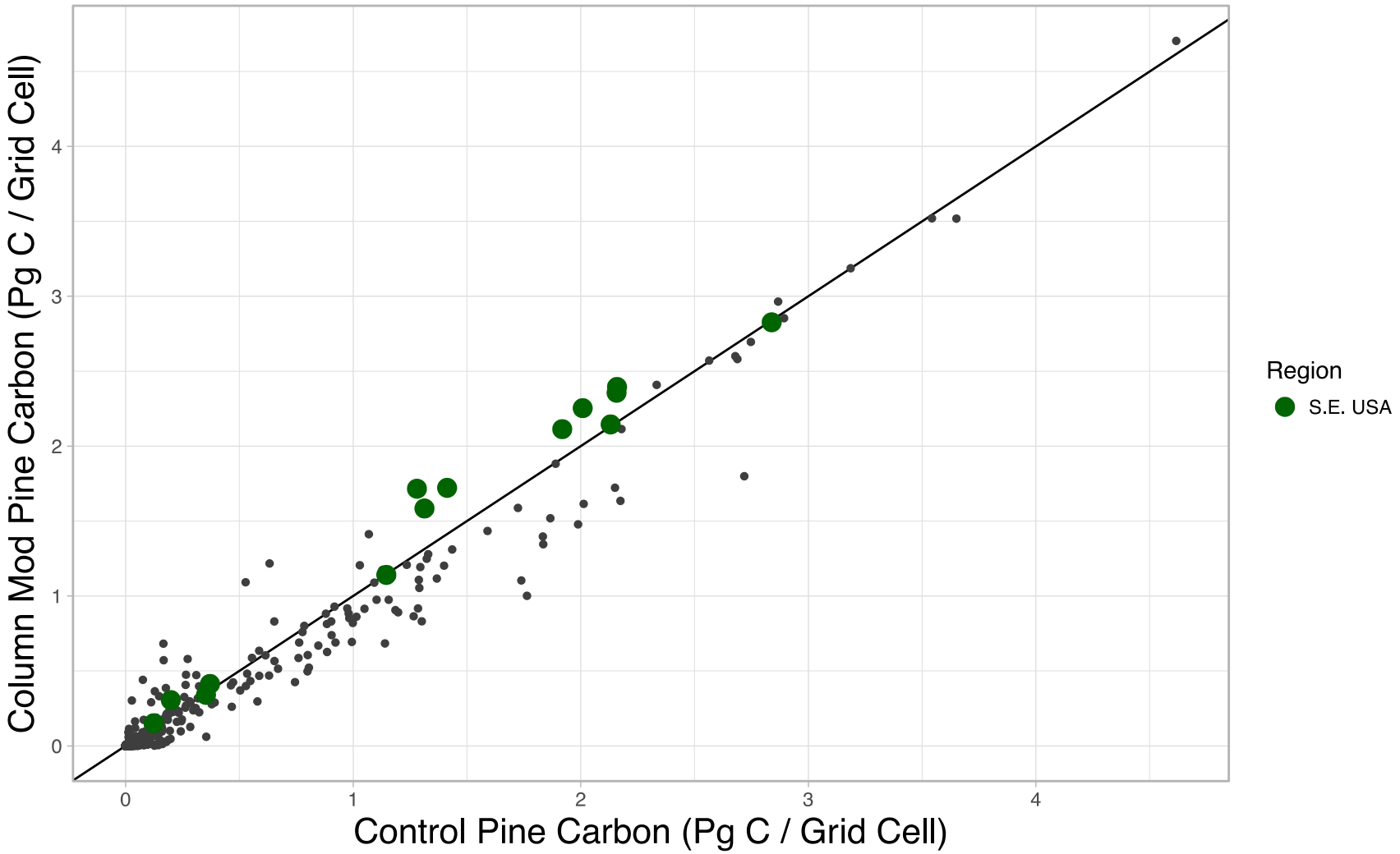
3165 Pg Total Eco C



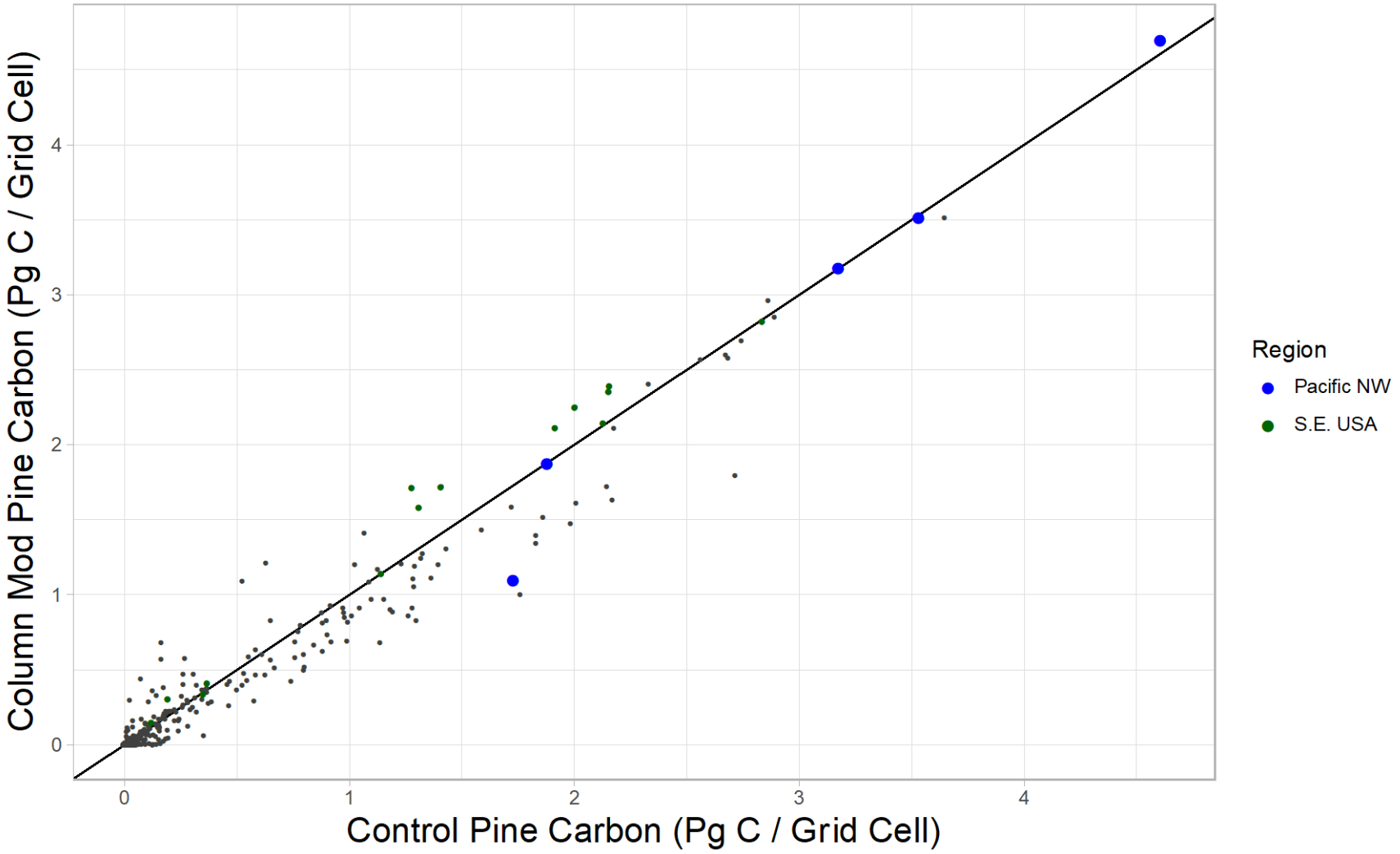
Relevant Evergreen Regions



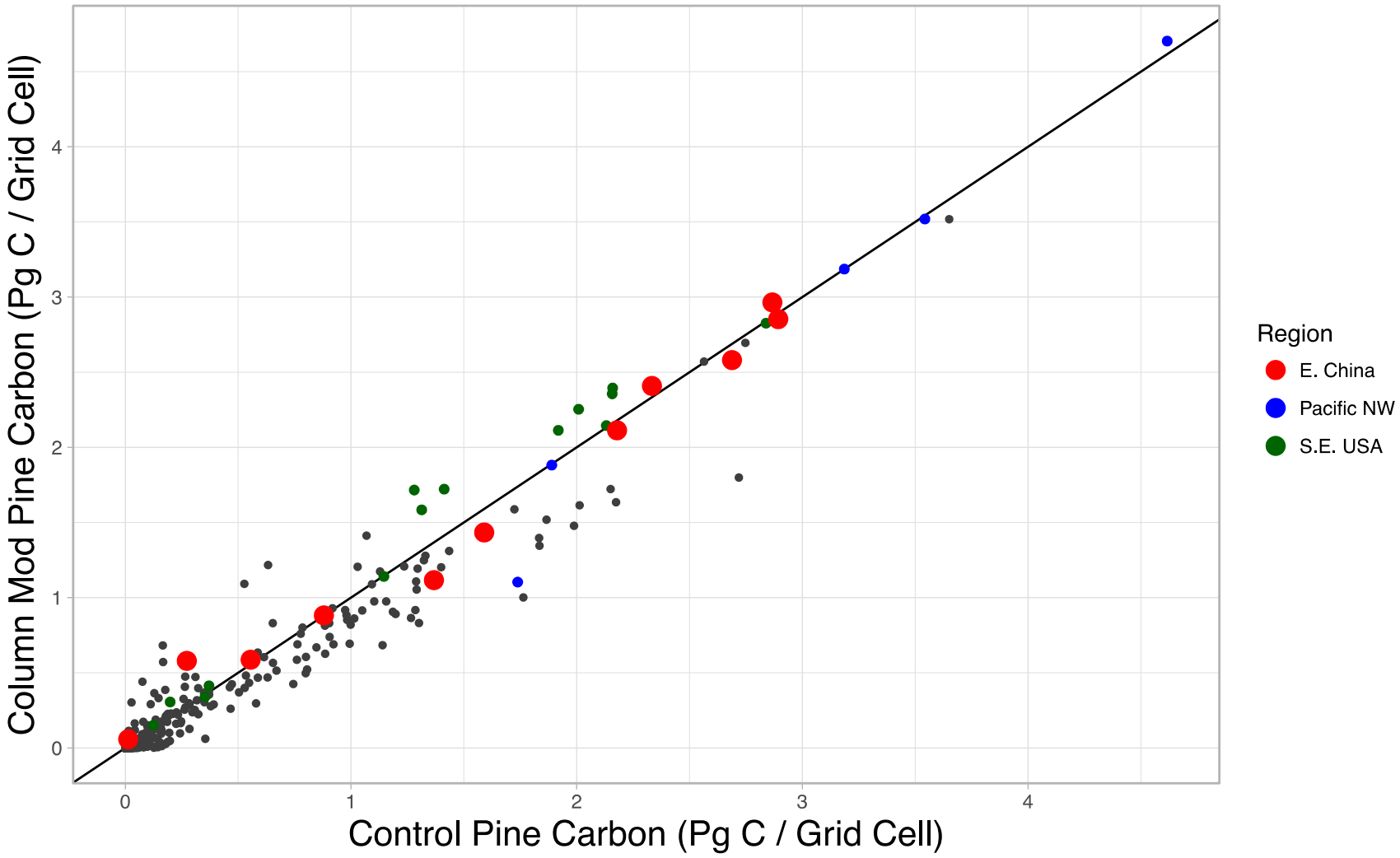
Temp. Evergreen C at Equilibrium



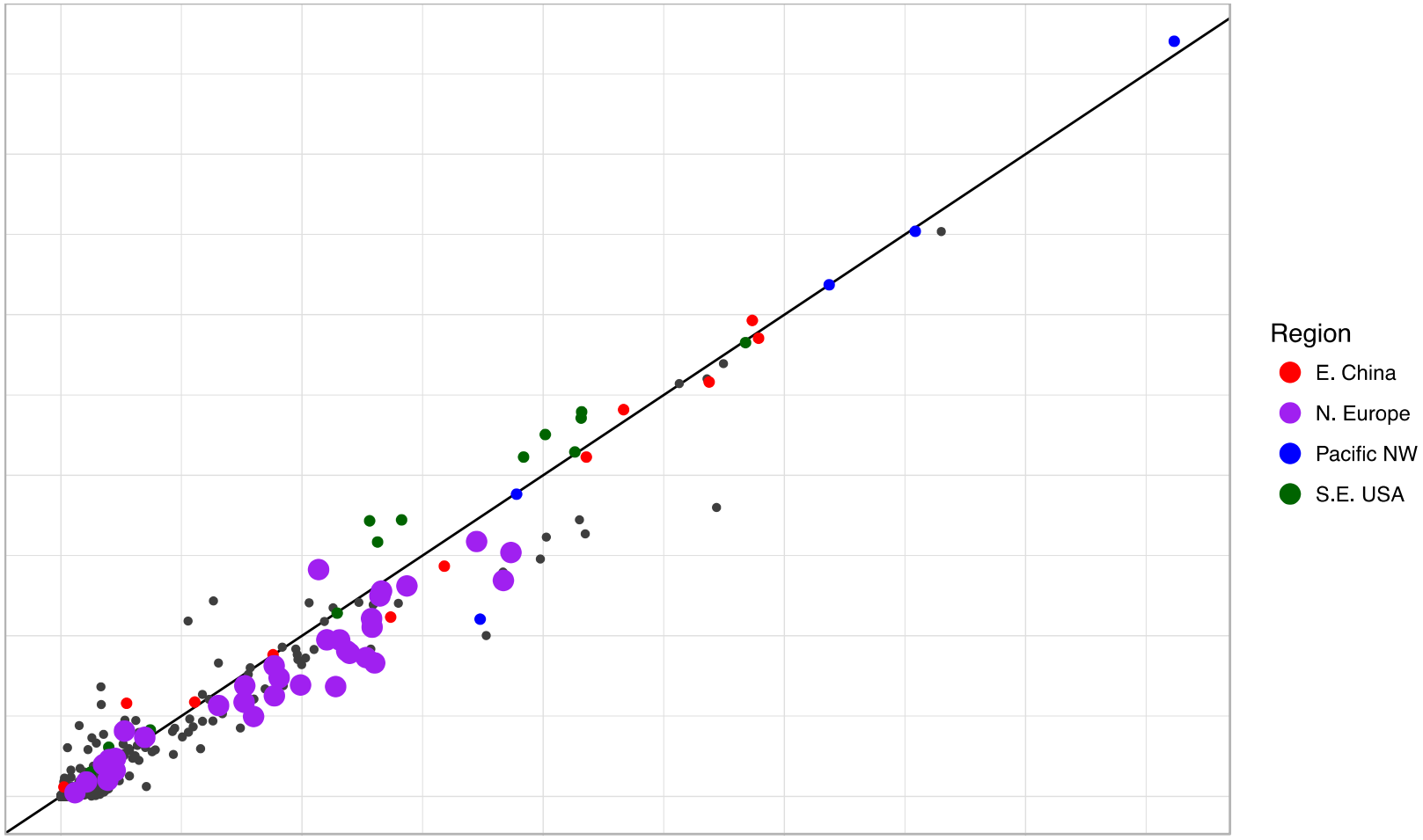
Temp. Evergreen C at Equilibrium



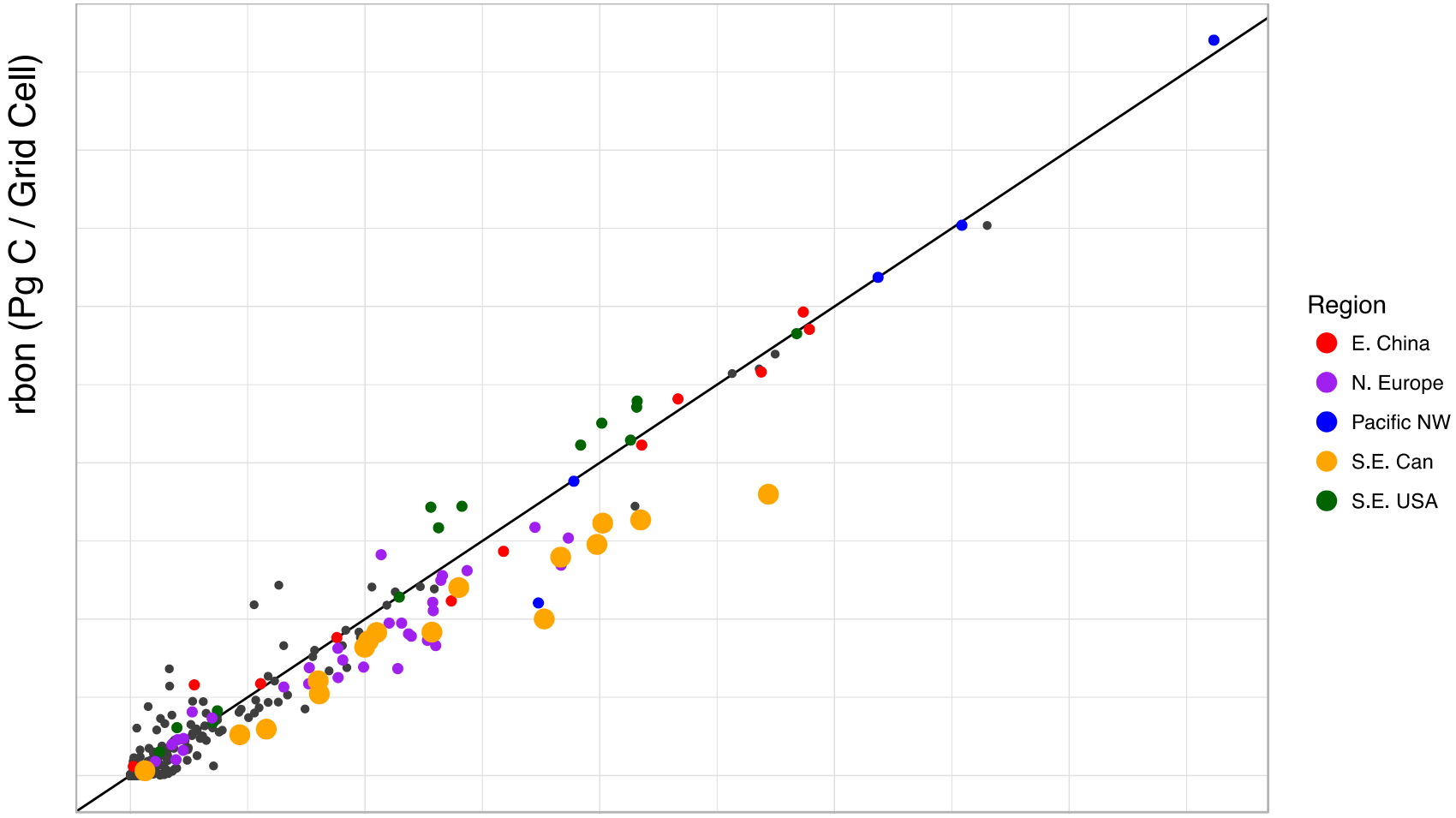
Temp. Evergreen C at Equilibrium



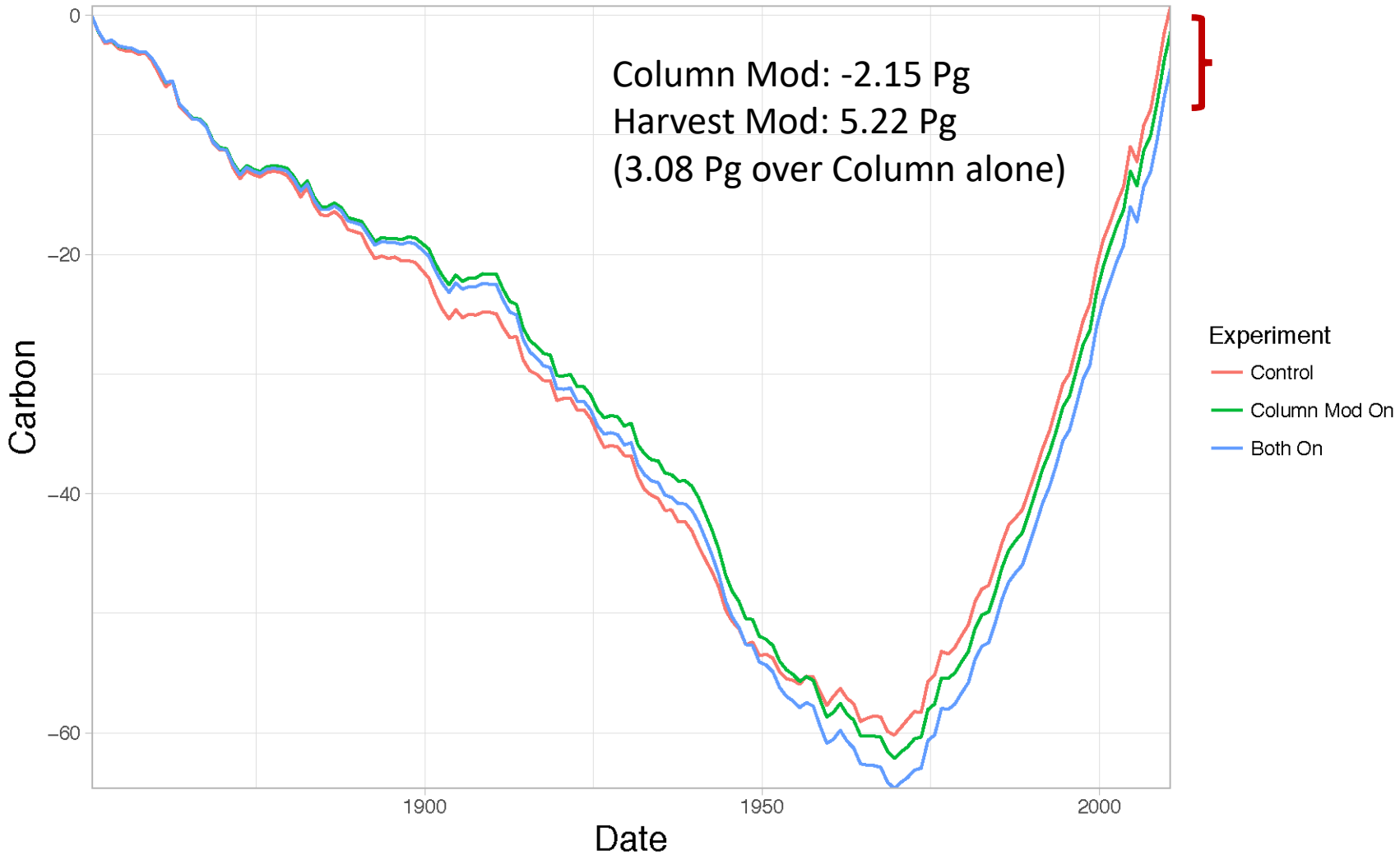
Temp. Evergreen C at Equilibrium



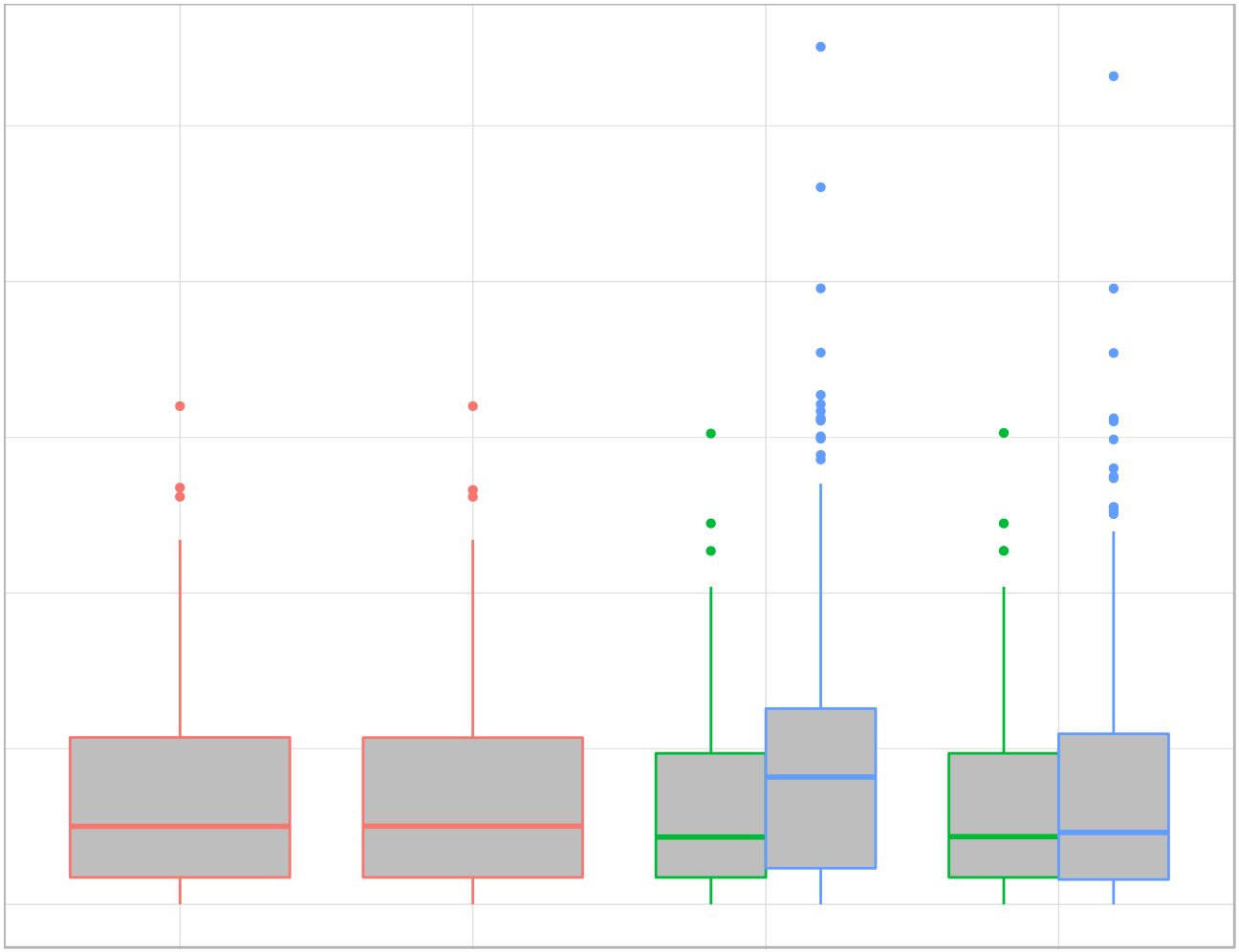
Temp. Evergreen C at Equilibrium



Transient Delta Carbon



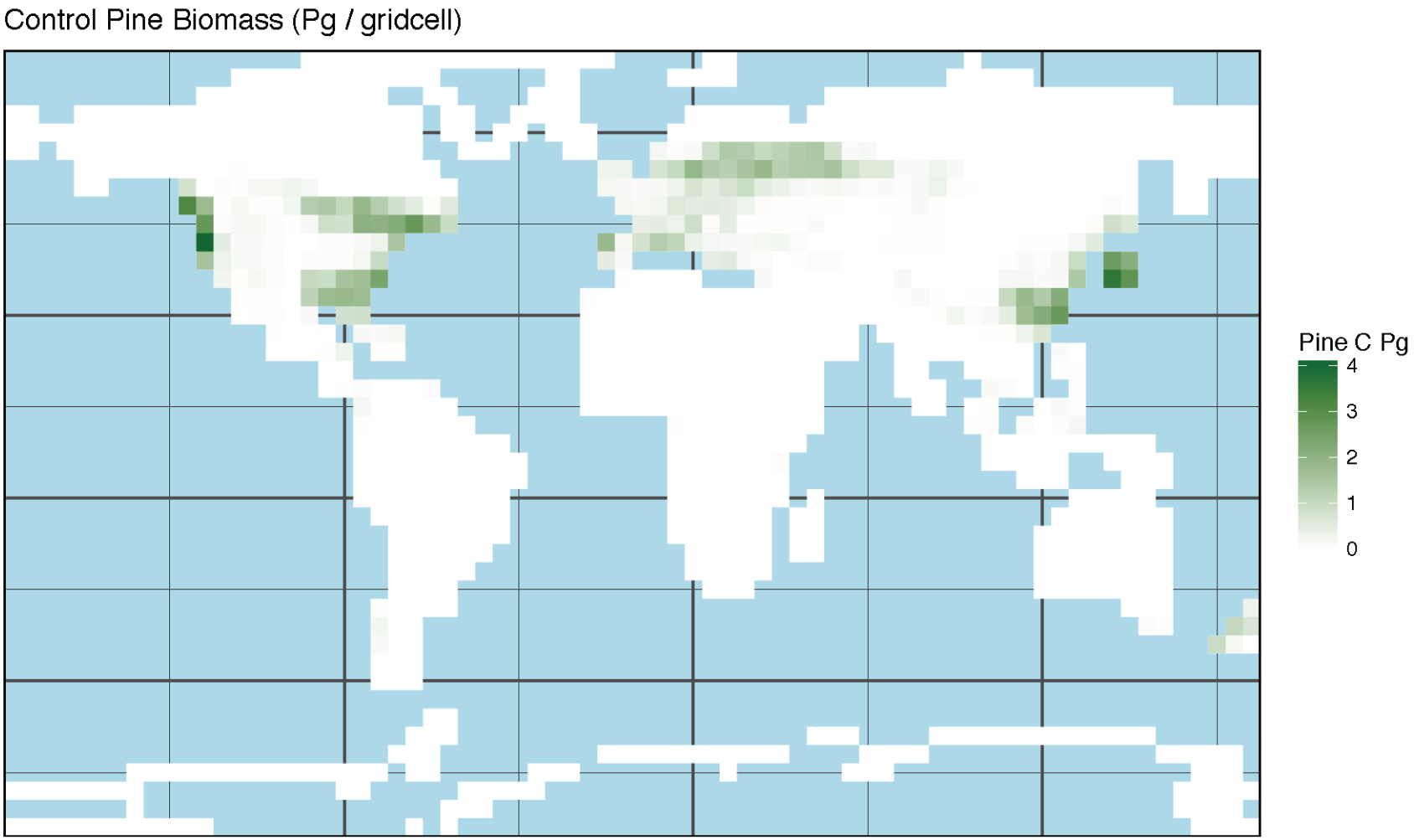
Soil Carbon at 2010



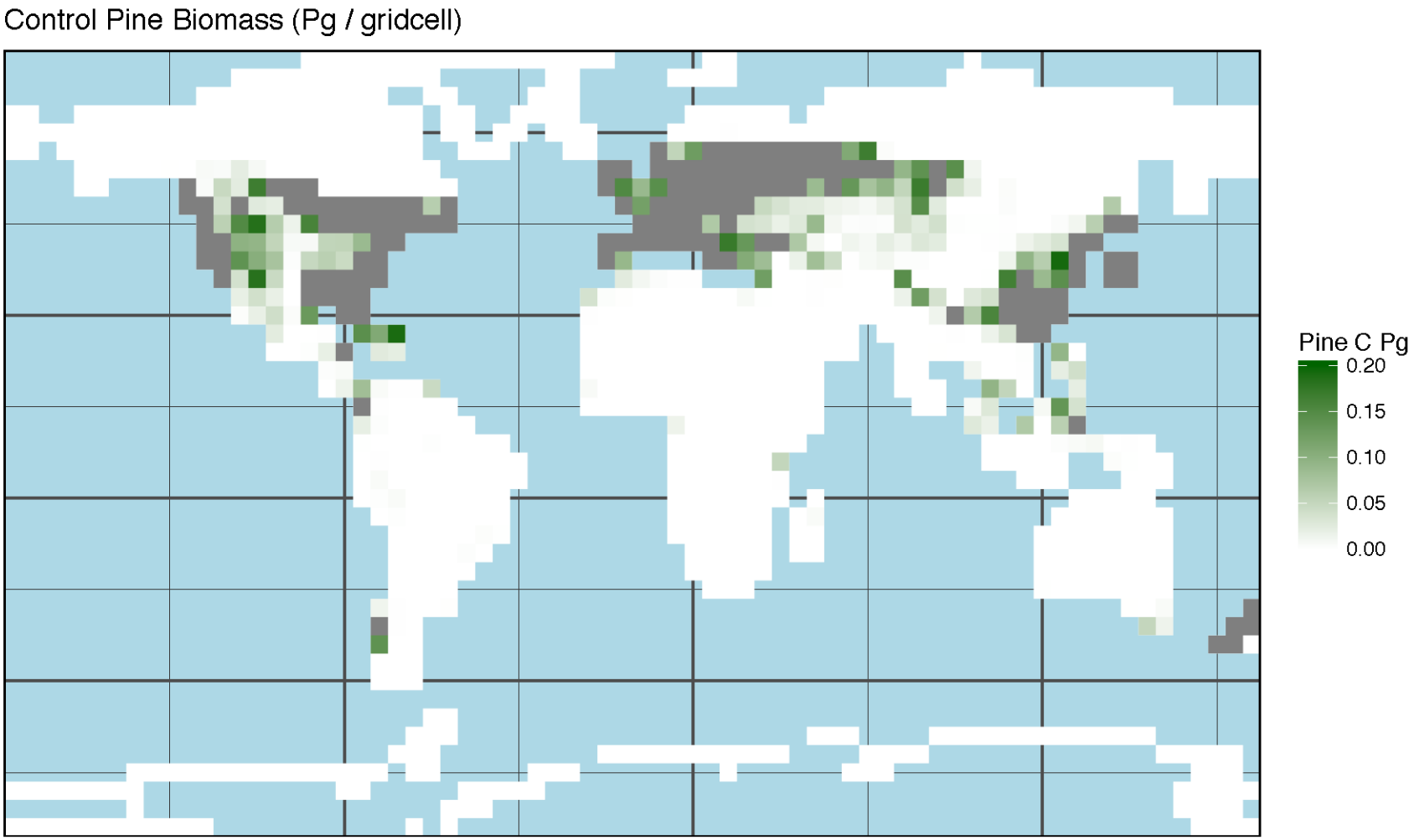
aged

Managed

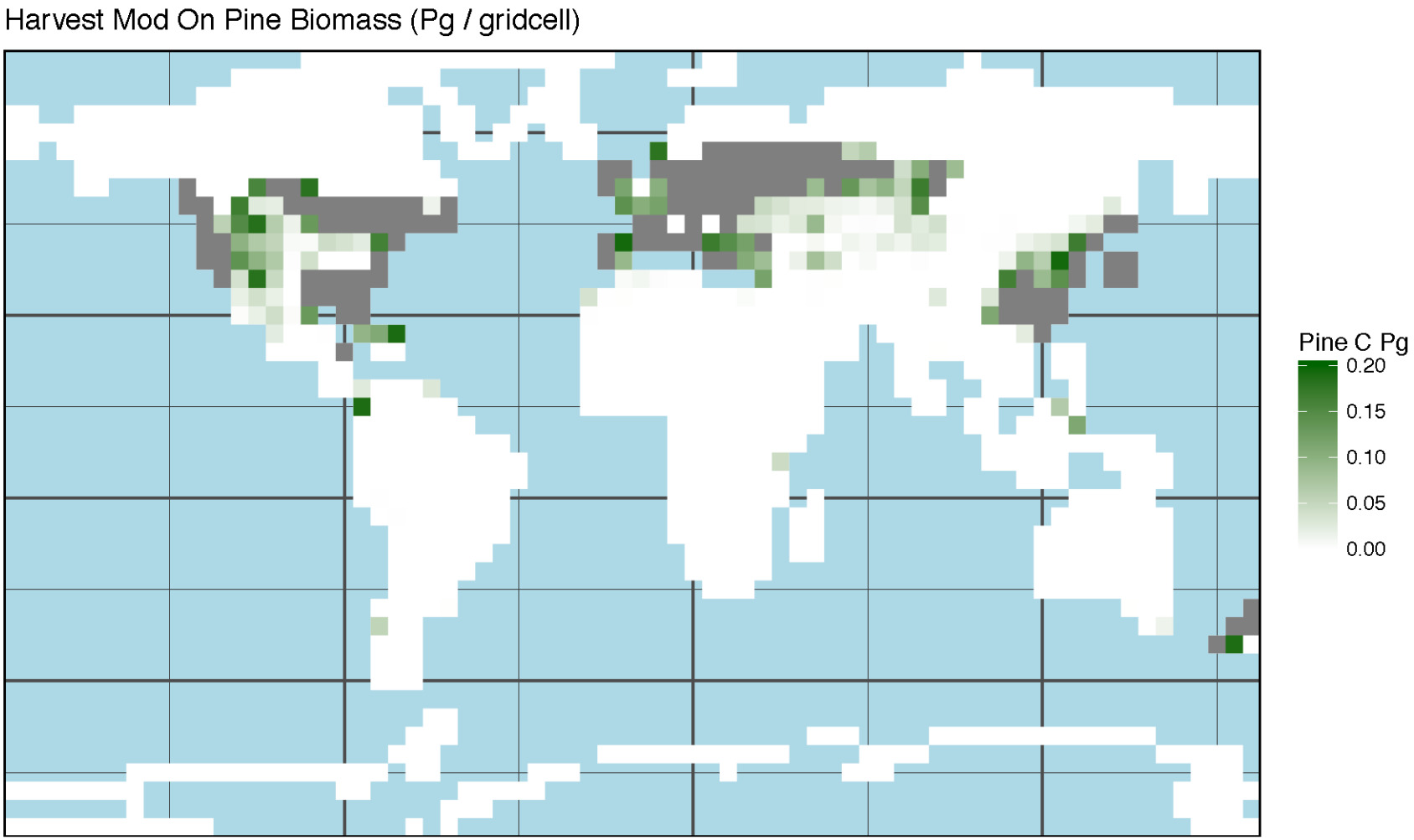
Pine Carbon: Control



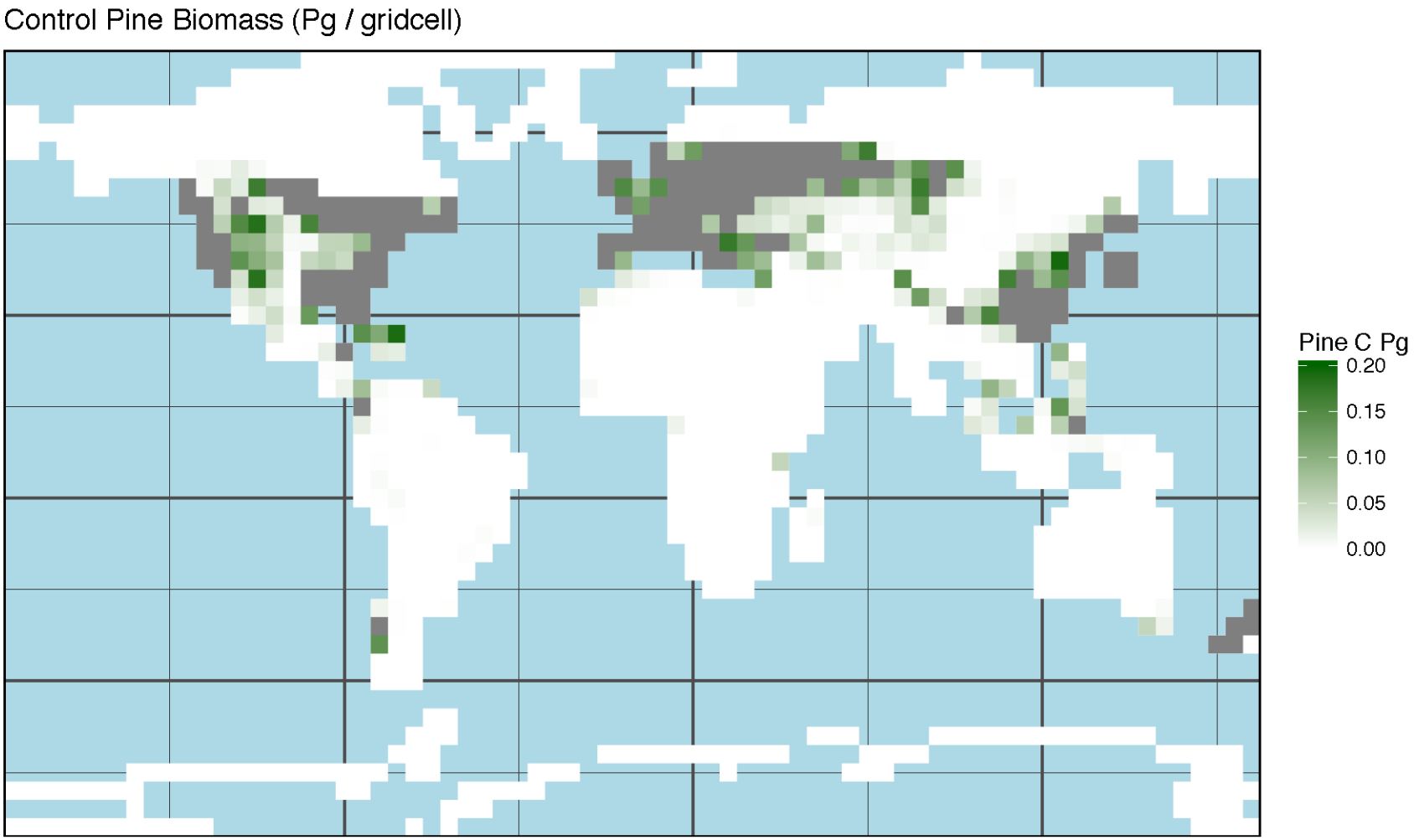
Pine Carbon: Control



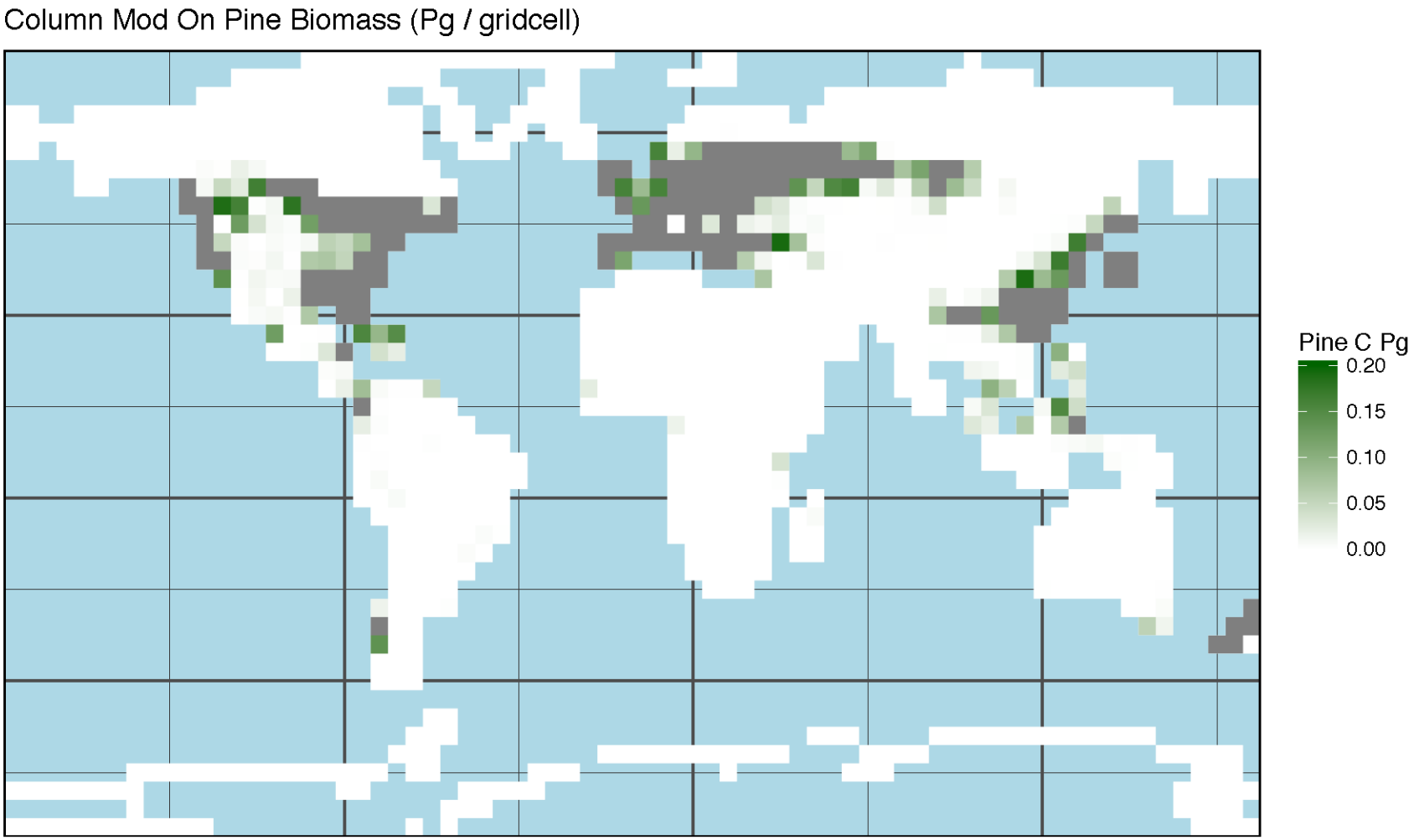
Pine Carbon: Harvest Mod On



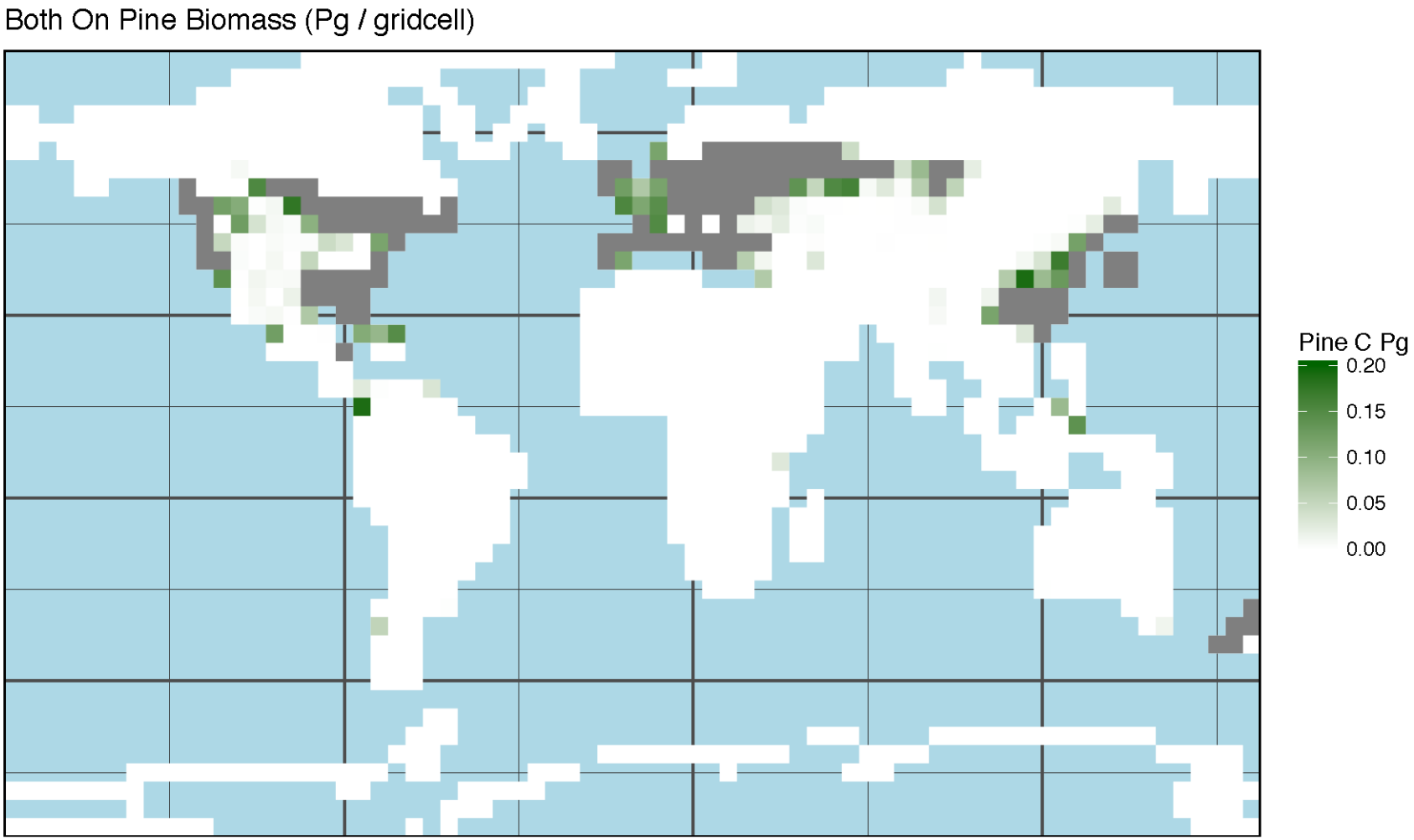
Pine Carbon: Control



Pine Carbon: Column Mod On



Pine Carbon: Both On



Conclusion

- We can now isolate PFTs, in part or in whole, on their own soil columns.
- We can harvest preferentially from a specific PFT.
- Modular & extensible implementation

- In regions where forest management is relavent:
  - Model induced changes are small and consitant
  - We should be able to control for changes in experiments

- Methods paper is in the works
- SVN branch **managedforests** almost ready to share

Future Directions

- Finish up this work:
  - Higher resolution, better settings (feedback appreciated)
- Column Mod Experiments:
  - Fertilization and Fire Suppression
- Further develop Preferential Harvest Mod:
  - Hierarchical harvest (this PFT then that PFT, etc.)
  - Map RCP harvest types in input files to PFTs
- Other:
  - Loblolly PFT Parameterization
  - Temperate evergreen phenology with greater seasonal variation in LAI

Acknowledgements

- Quinn Thomas Lab & Collaborators
  - **R. Quinn Thomas**
  - Ben Ahlswede, Kevin Horn
  - Thomas O'Halloran, Clemson University
- FREC Colleagues at Virginia Tech
- VT Global Change Center & Global Change IGEP
- NCAR Faculty, Staff, and Colaborators
- USDA-NIFA Project 2015-67003-23485

United States Department of Agriculture

National Institute of Food and Agriculture