Harvesting more wood from less area: Simulating the intensification of forest management in the CLM

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National Center for Atmospheric Research

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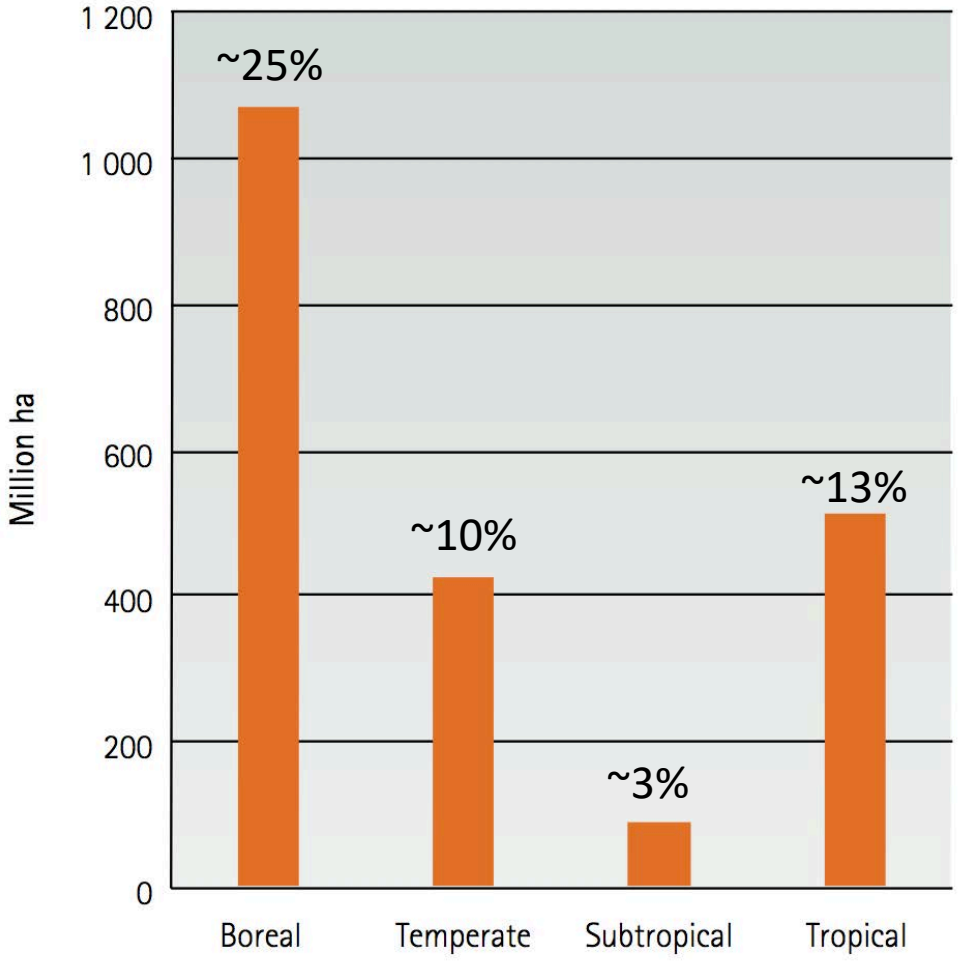
50% of global forests have a management plan

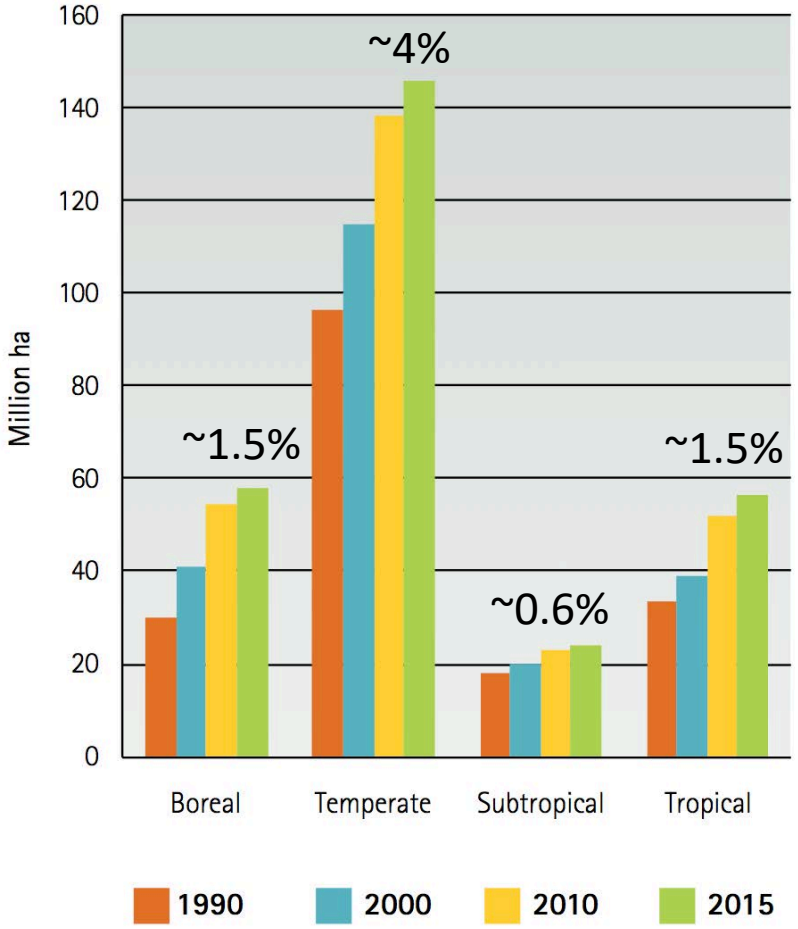


- Forest area that has a long-term documented management plan, aiming at defined management goals, which is periodically revised.
- Must include adequate detail on operations planned for individual operational units (stands or compartments) but may also provide general strategies and activities planned to reach management goals.

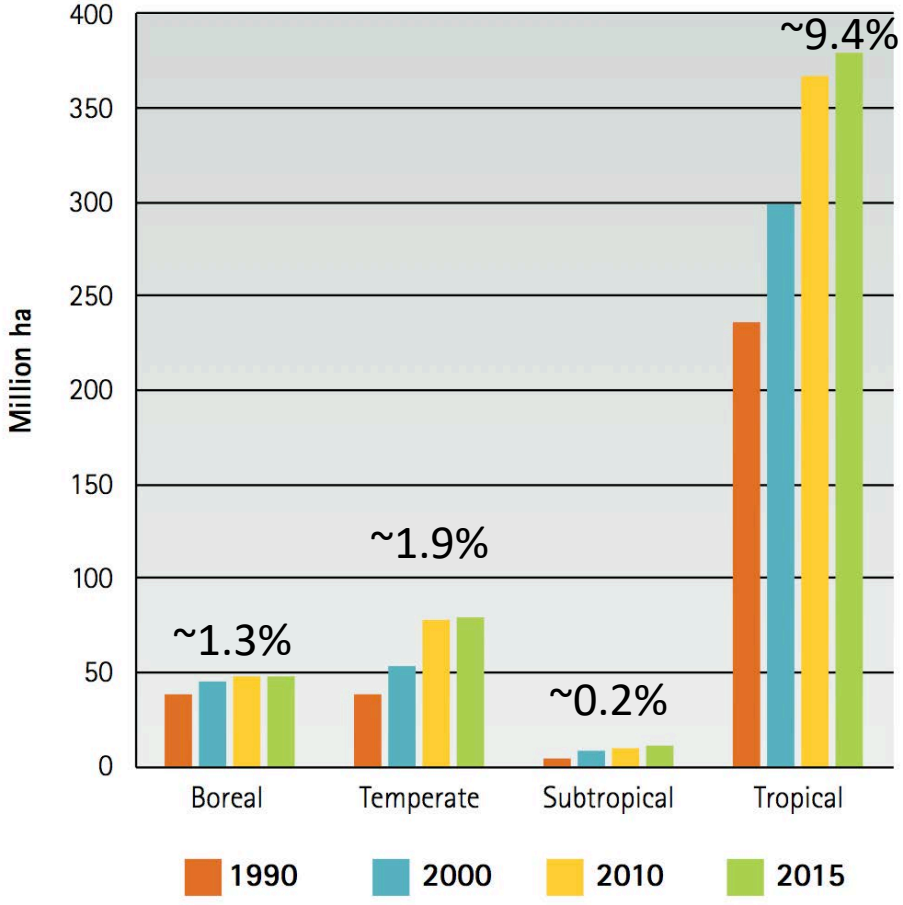
FAO 2015

Management: preservation vs. production (~20% of global forest area)

Area of planted forest

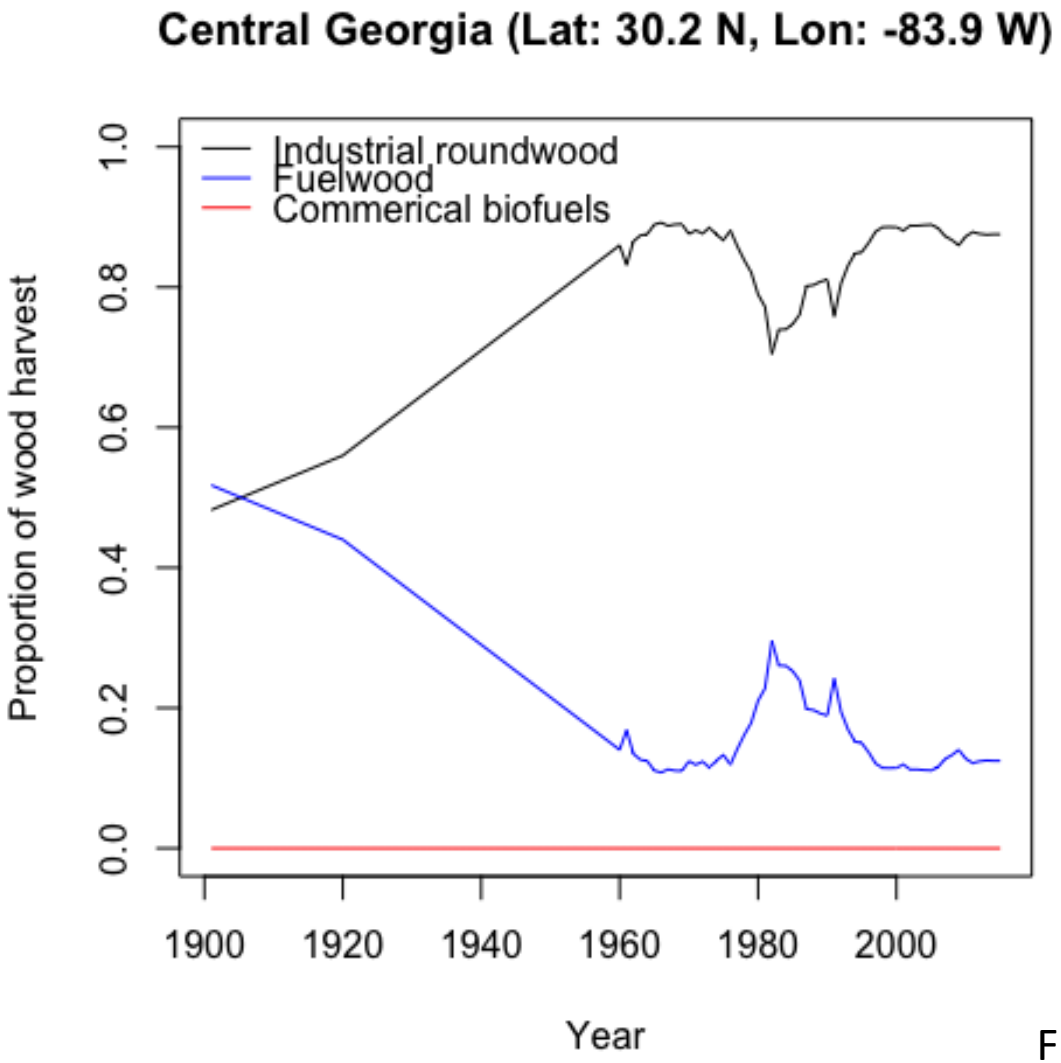


Area of protected forest



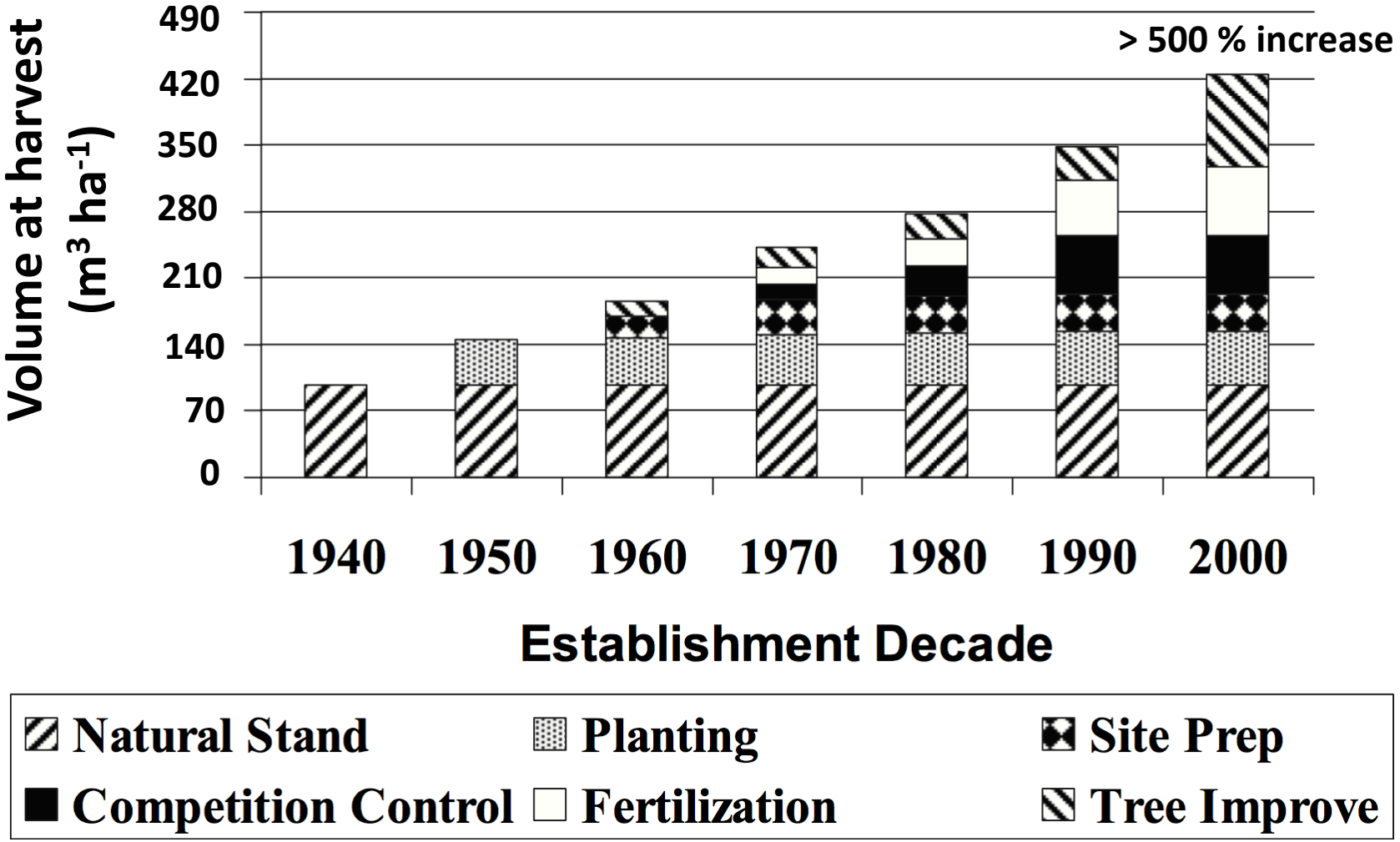
FAO 2015

CMIP6 Land-use drivers: Forest management



From Hurtt, Chini et al.

Influence of management on productivity

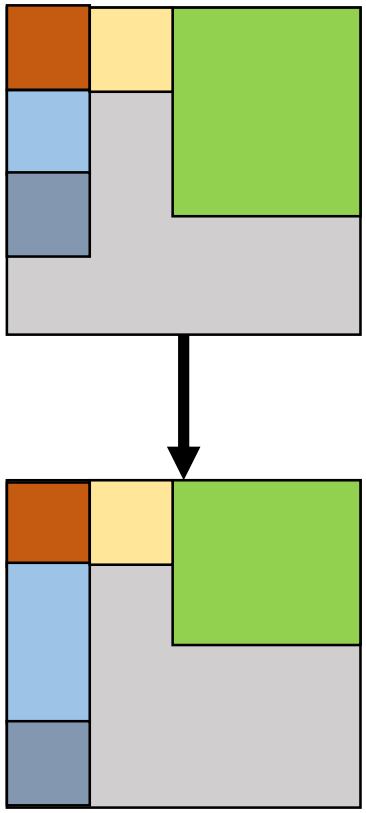


Fox et al. 2007

What is forest management at the Earth system scale?

- Species selection
  - 20% of tree volume in the US is from two species (Douglas-fir and loblolly pine)
- Tree Improvement
  - Optimizing the genetics to grow fast and be adapted to climate through modifications either to physiological or allocation parameters
- Fire management
- Nutrient addition
- Site preparation at planting
  - Influence on soil carbon?
- Thinning
  - Reductions in LAI may influence drought sensitivity

New features of CLM that we can leverage for the project (thanks team!)



- Dynamic land-units with conserved biogeochemistry
- Flexibility to add new PFTs
- Harvesting on either a mass or area basis
- Nitrogen fertilization to a column

Overarching questions

Will assigning the harvest from the land-use drivers to a highly managed proportion of the grid-cell influence the terrestrial carbon sink over the 21st century

1) Better able to respond to atmospheric CO_2 (young and fertilized)
2) Allows for protected forest to build up soil carbon because the forests do not have removals
3) Having lower average LAI on plantation grid cells *may* result in lower sensitivity to drought
4) Potentially able to have quicker acclimation to climate by moving seeds and seedling from warmer locations

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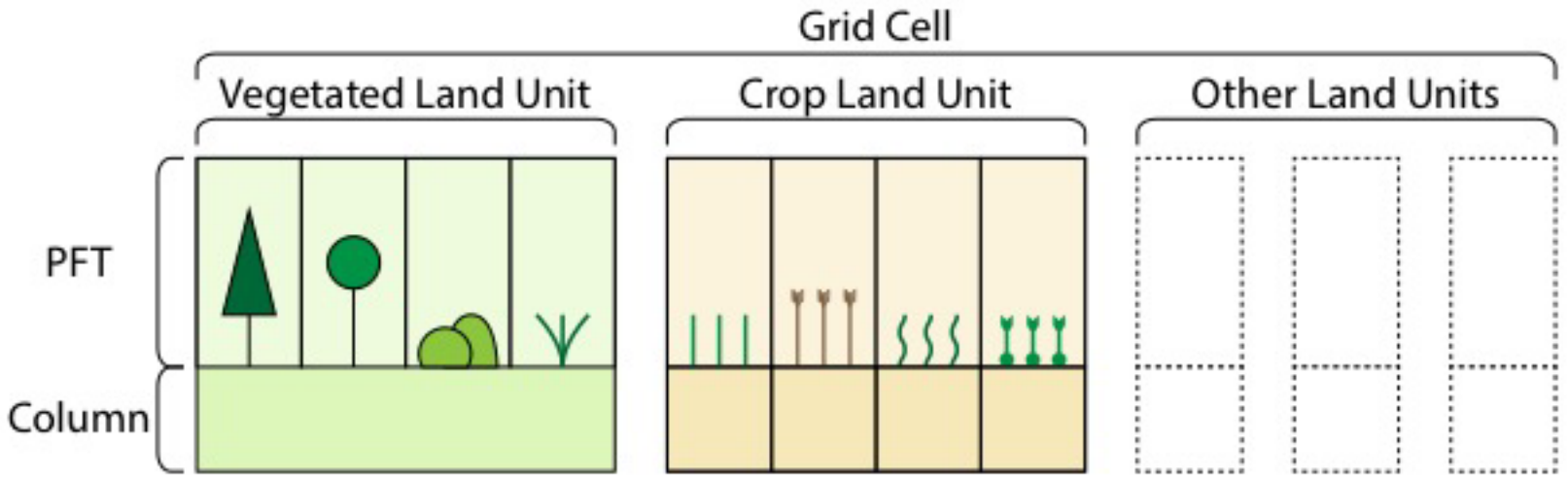
How will timber yield respond to climate change?

Step 1: Create a managed forest plant functional type

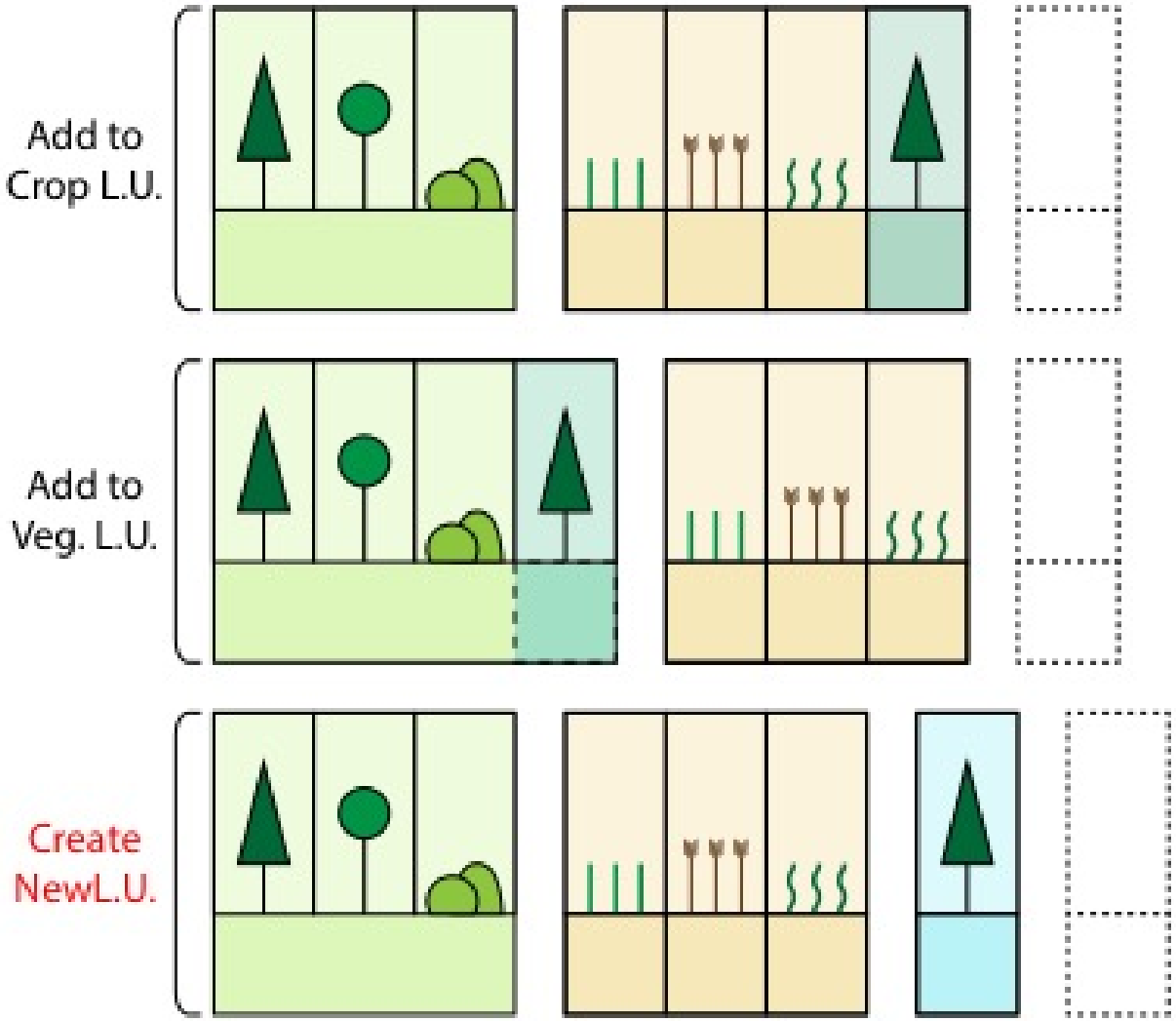
Where should we put intensely managed forest PFTs?



Managed Forest Tree PFT Goals

- Act like a tree in most ways
- Add additional management behaviors
  - Some are crop-like (CLM)
    - **Fertilization**
    - Irrigation
  - **Cultivar selection (unique PFT parameterization)**
  - Forest rotation and discrete harvest events (future application of FATES)
  - Thinning mid-rotation (future application of FATES)
- Add some column level management behaviors
  - Modifications to litter decomposition (soil disturbance)
  - Modifications to fire regime
- **Prioritize harvesting off the management forest column**

Candidate Approaches



Arguments

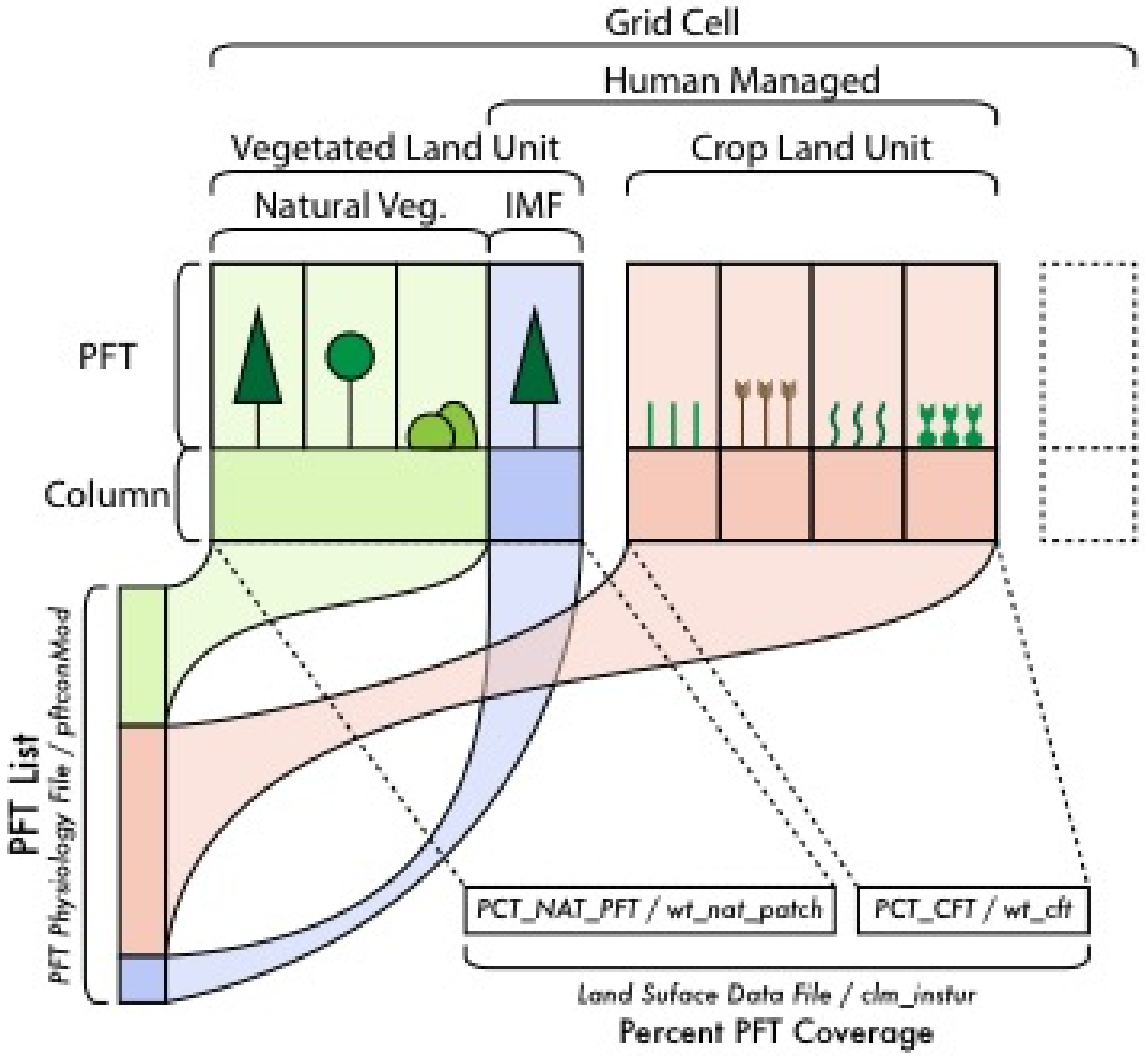
Crop Land Unit

- Pros:
  - Conceptually “human managed”
  - Separate Column
- Cons:
  - Crop model must be on
  - Don’t need most crop behavior
    - Must turn off for new PFTs in many places
  - Complicates PFT weights

Vegetation Land Unit

- Pros:
  - Treated like trees
  - PFT weights comparable
  - *(Competition possible)*
  - Land Unit aggregation of PFT variables
- Cons:
  - Shares column: thus competition
  - Must code in new PFTs (indexes &IDS) to L.U.

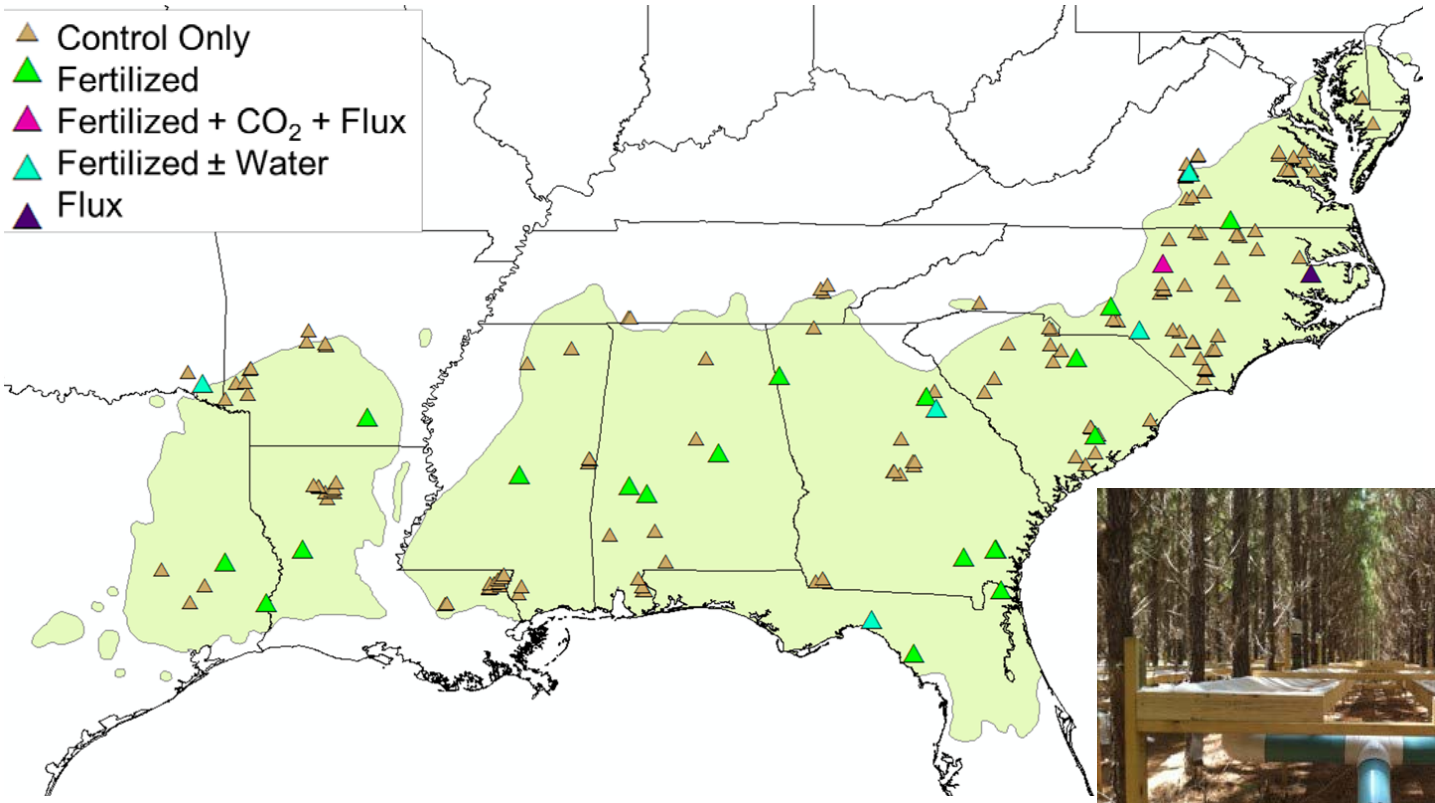
Selected Approach



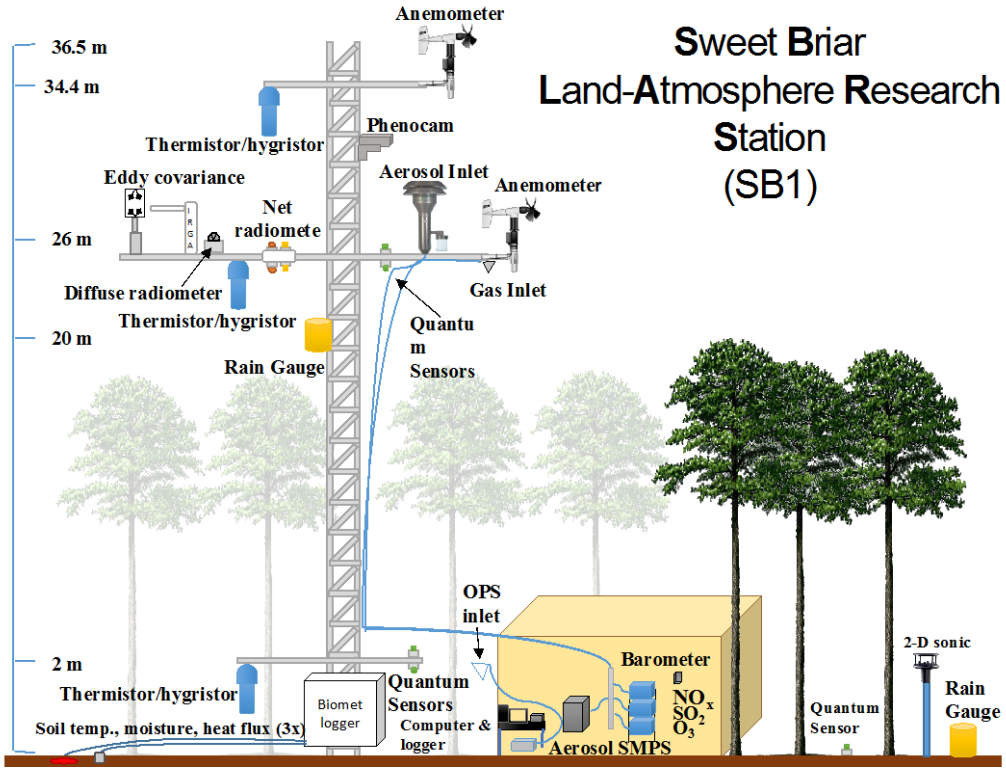
Technical Change Summary

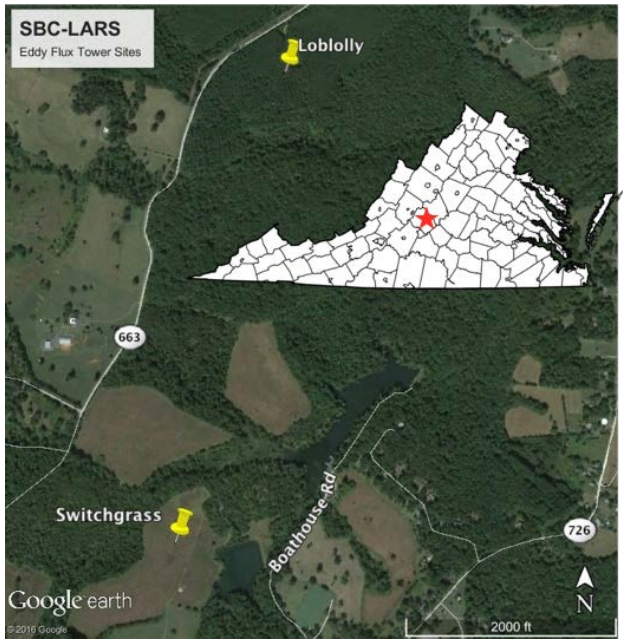
- PFT Logic:
  - Make crop logic consistently respect upper limit (npcropmax)
  - Add new PFT to vegetation conditionals
  - Modify some filters (pcropp)
- Input Files:
  - Modify PFT Parameter File (new PFTs added to end of list)
  - Modify Land Surface File:
    - Managed Forest PFT weights added to PCT_NAT_PFT
  - Modify code that loads data
- Give new PFTs their own column in the natural vegetated land unit
  - Modify code that assumes all vegetated PFTs will be in a single column
  - Add code to give the new PFTs their own column

Step 2: Parameterize the PFT



Loblolly pine flux tower (US-SB1)





Developing a regional parameterization for allometry using a simple model linked to CLM

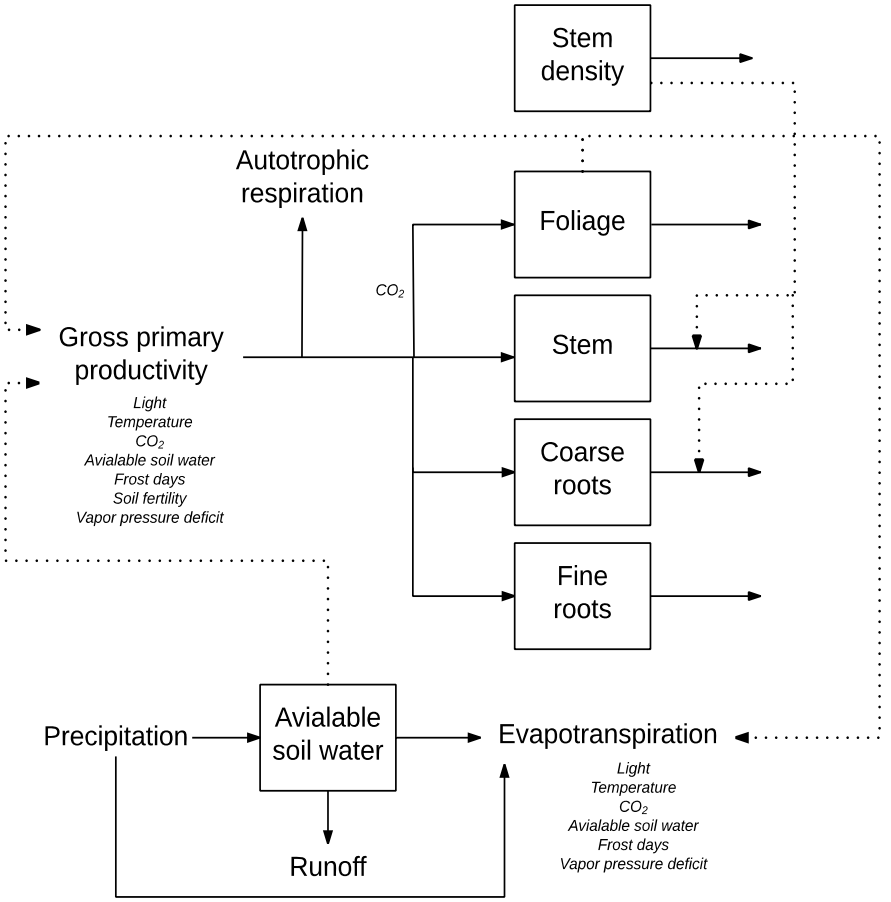
Data streams

Stem biomass
Coarse root biomass
Fine root root biomass
Foliage biomass turnover
Fine root biomass turnover
Pine stem density
Leaf area index
Gross ecosystem production
Evapotranspiration

300 plots

Control
Nutrient fertilized
Water addition
Throughfall exclusion
Elevated CO_2

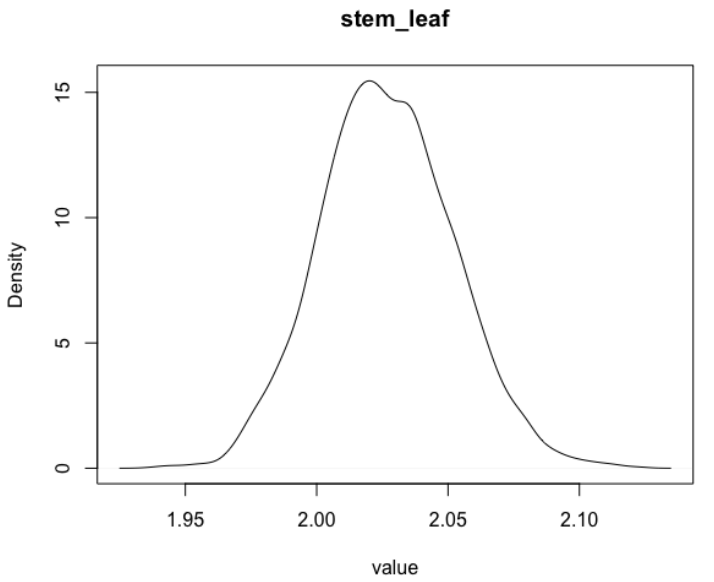
Simple monthly productivity model (3PG)

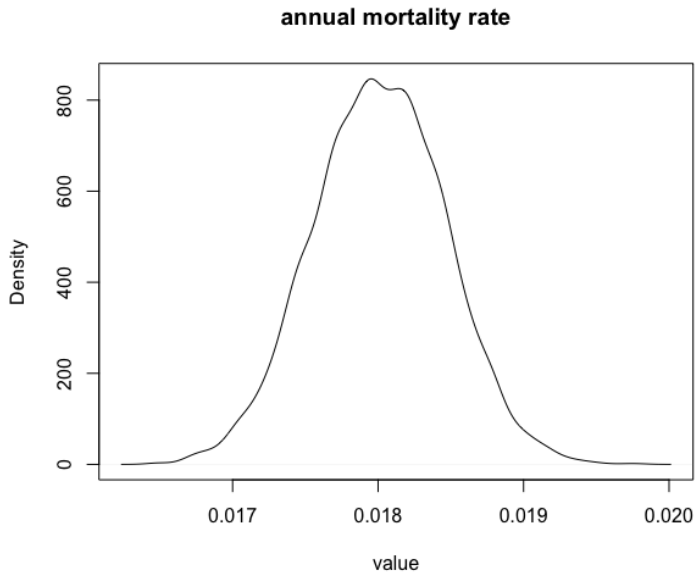


Developing a regional parameterization for allometry

Key parameters

- stem_leaf
- leaf_long
- froot_leaf
- am
- croot_stem
- slatop
- dsladlai
- froot_turnover





Step 3: Modify surface and land-use history inputs to include managed tree PFTs across the globe

Can we make forest management plans an optional input to the the CLM?

- Forest preservation
- Production forestry
- Passive management (harvesting but little management)


Questions?