Towards forestry in the Community Land Model

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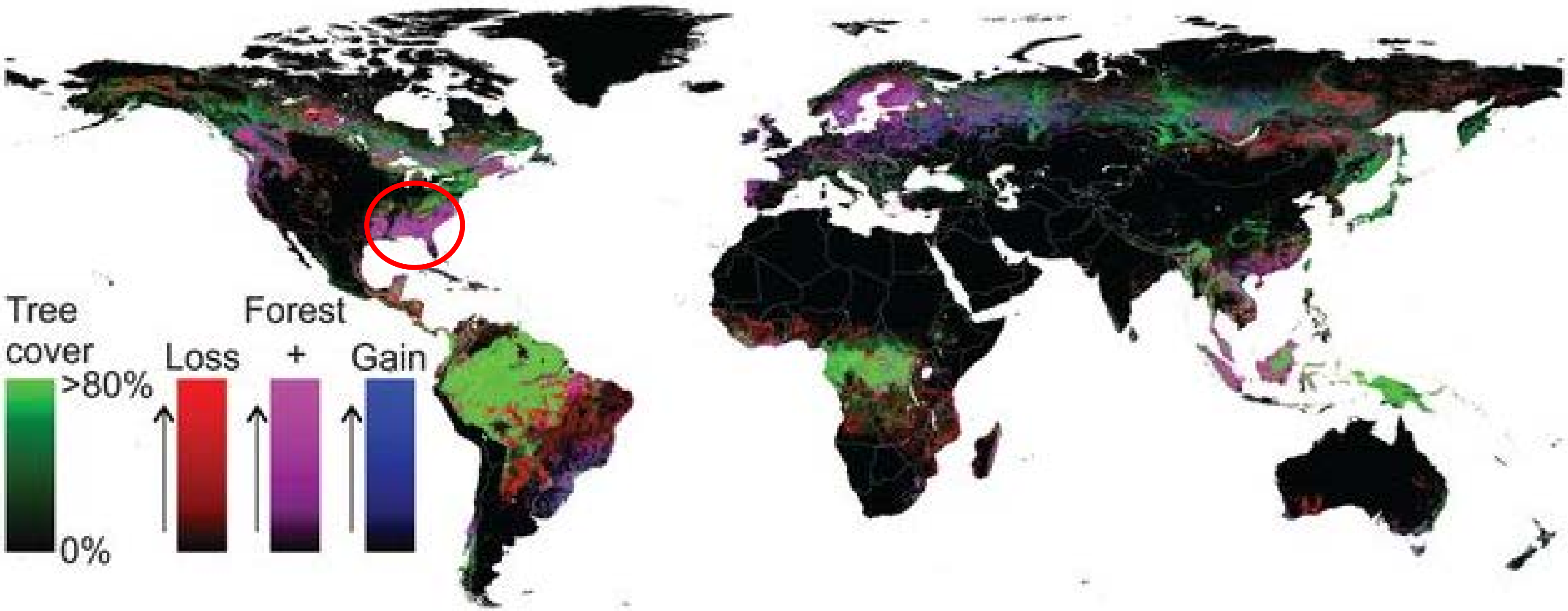
Invent the Future

Forest management is widespread across the globe



Purple = exited and entered forest classification during the 2000s

Hansen et al. 2013

Conceptually what is forest management?

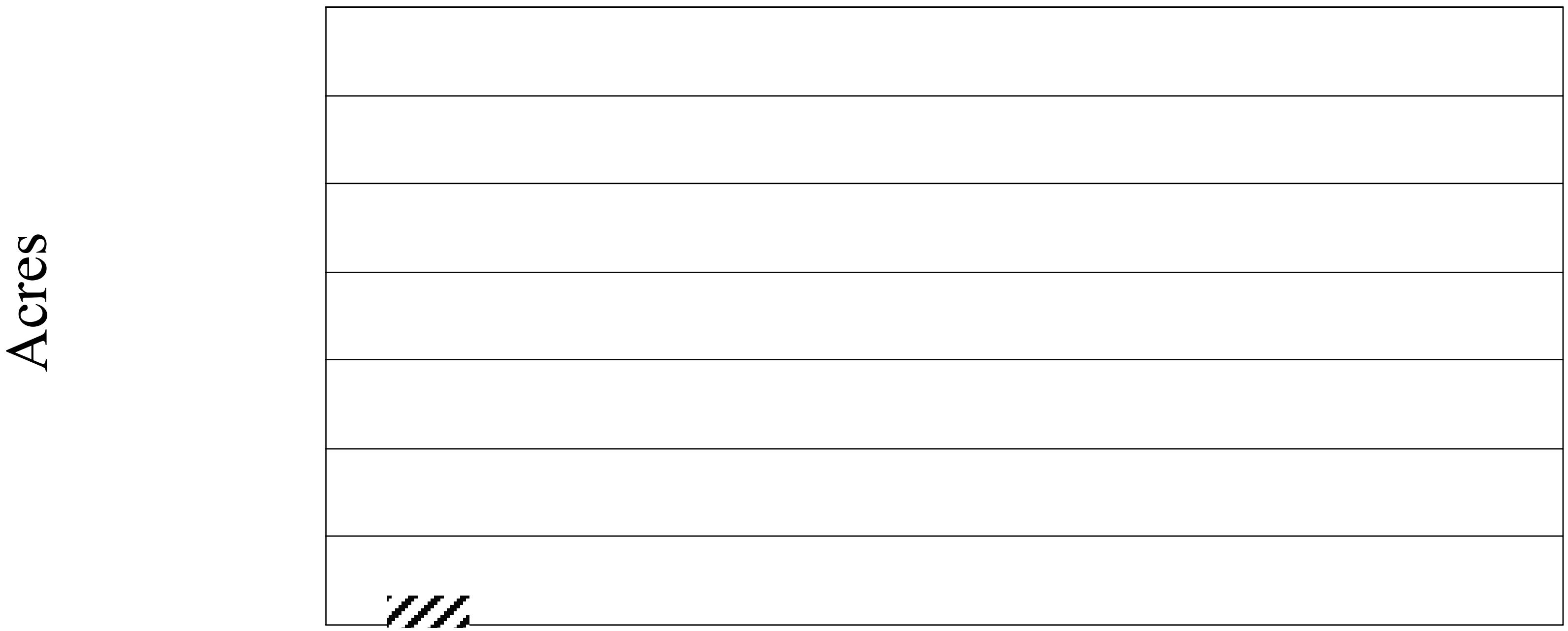
Duncker *et al.* 2012 *Ecology and Society*

- Extensive/Passive/Low Input
  - Forests grow with little management inputs
  - Close-to-nature forestry
- Intensive
  - Forest with significant management inputs
  - High productivity per land-area
  - Even-aged
  - Can include shortened rotations

Where to plant -> what to plant -> how to manage it

Southern Pines as an example: Intensification has been widespread

Area of pine plantation forestry in the Southern U.S.



Fox, Jokela, and Allen 2007

Southern Pines as an example: Intensification has become more intense

Increase in yields and the associated management inputs

Focus on volume of wood →

Fox, Jokela, and Allen 2007

How might forest management influence climate?

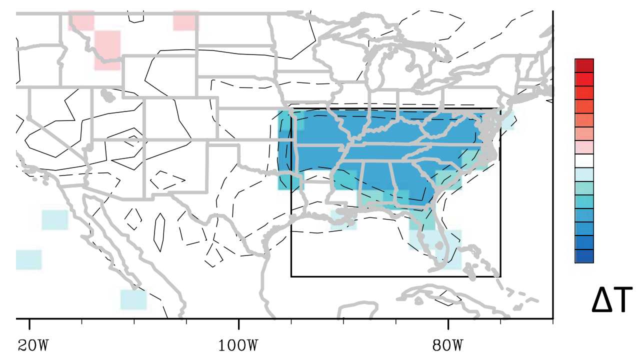
- Carbon cycle
  - Increased productivity
  - Must account for wood products as well
  - Yields ≠ NEP
- Nitrogen cycle
  - Fertilization influencing N_20
  - Higher growth rates decreasing N losses?
- Albedo
  - Shorter rotations = more soil exposed and lower LAIs
- Latent and Sensible heat through changes in surface roughness or stomatal conductance
- BVOC production?

Focus on both land-cover and land-management

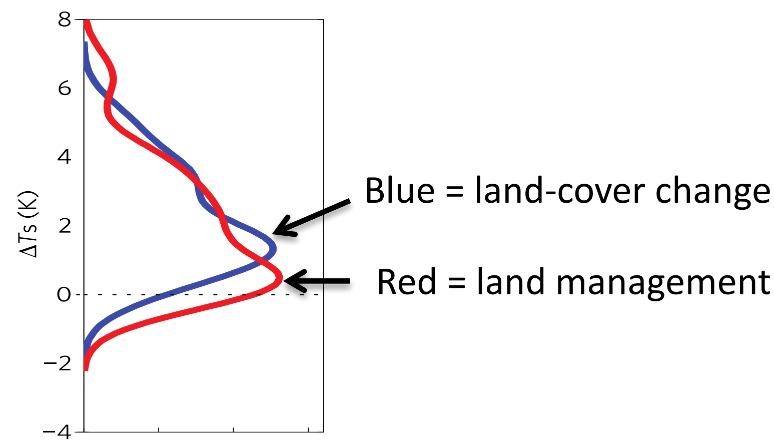
1 July 2012 JOURNAL OF CLIMATE

Simulated Local and Remote Biophysical Effects of Afforestation over the Southeast United States in Boreal Summer*

Guang-Shan Chen, Michael Notaro, and Zhengyu Liu



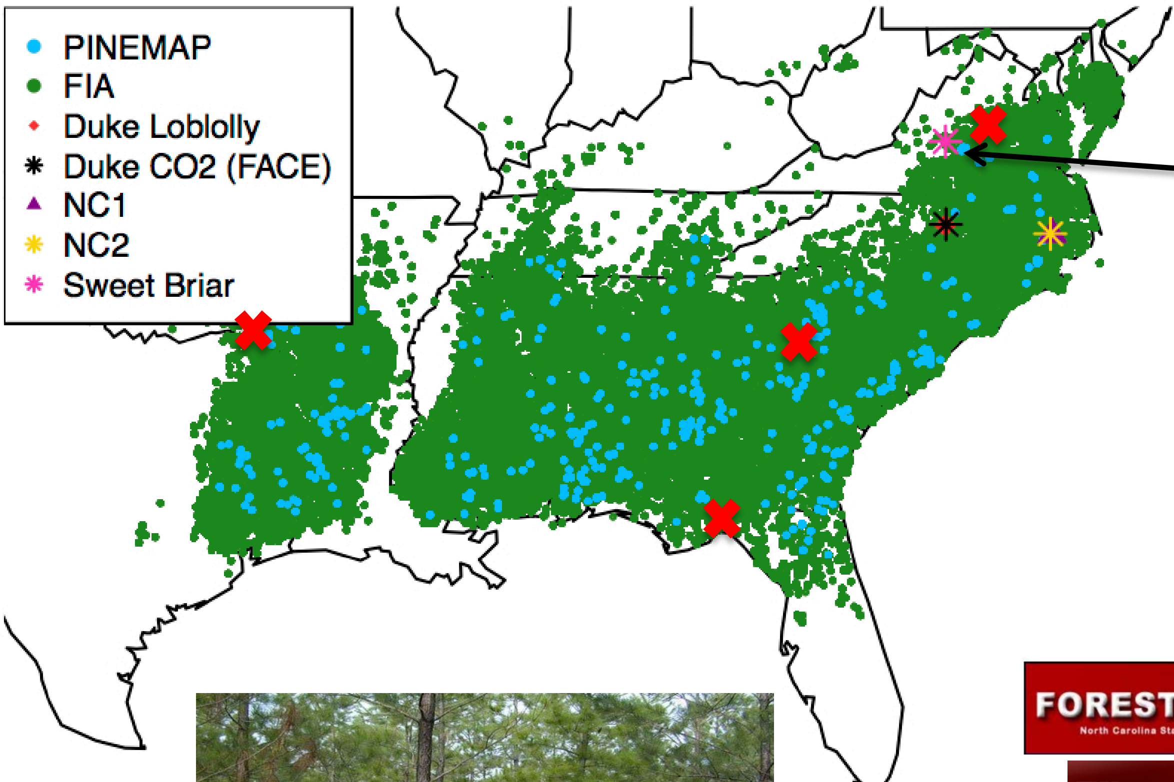
nature climate change



Big questions using the CLM

- How do different management activities influence climate?
- Can we meet societal demand for wood products while having a positive or neutral influence on climate?
- What details of forest management are globally relevant in the CLM?
- How does explicit forest management interface with new CMIP6 land-use forcing?

Data availability for model development and evaluation



New tower: Tom O'Halloran (Sweet Briar College) and Virginia Tech collaboration

Tom Fox

Harold Burkhart

PINEMAP

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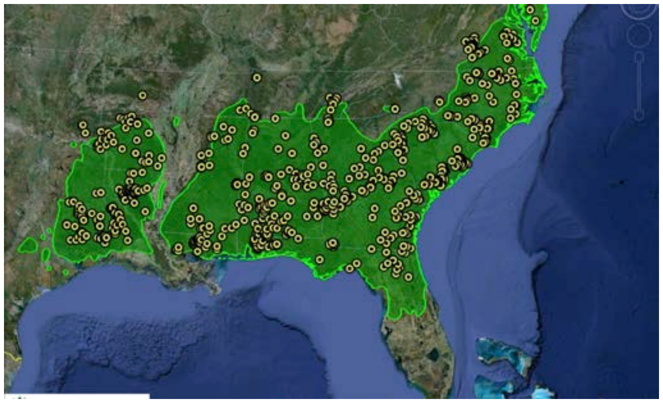
AMERIFLUX

✖ 4-year rainfall exclusion experiment

Examples of forestry Trial Data

Nutrients, spacing, thinning, genetics, weed/hardwood control



RW25	Nutrient Omission Design for Eucalyptus	2010-2016
RW24	Cold-hardy Eucalyptus for the SE US	2010-2016
RW23	Intensity and duration of weed control	2010-2011
RW22	Twin-plot network in pine plantations	2010-2011
RW21	Twin-plot network in Eucalyptus plantations	2010-2012
RW20	P. taeda variety and silviculture in the southeastern US and Brazil. Varieties have differing crown ideotypes	2009-2010
RW19	Thinning x fertilization factorial in P. taeda plantations	2006-2009
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RW18	Optimal rates and frequencies of nutrient application. P. taeda in southeast US and Argentina, E. grandis in Colombia	1998-2006
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RW17	Fertilization x vegetation control factorial at midrotation. Pines and hardwood crop trees monitored	1996-2002
RW17	Fertilization x vegetation control factorial at midrotation. Pines and hardwood crop trees monitored	1996-2002
RW16	Surface x subsurface tillage factorial at establishment. All plots receive weed control. Primarily upland clay and clay loam sites	1994-2000
RW15	Combinations of N, P, K, and micronutrients in established stands. Also, in Pinus radiata in Chile	1989-1999
RW15	Combinations of N, P, K, and micronutrients in established stands.	1989-1999
RW14	Control, 45N, 50P, 100K combinations, and delay and repeat fertilization at establishment on primarily Gulf Coastal Plain sites	1989-1998
RW13	Midrotation fertilization with factorial combinations of N and P for P. taeda in the US and P. radiata in Chile	2002-2016
RW13	Midrotation fertilization with factorial combinations of N and P for P. taeda in the US and P. radiata in Chile	2002-2016
RW11	Control, 45N, 50P, 100K combinations, and delay and repeat fertilization at establishment on primarily Gulf Coastal Plain sites	
RW07	Site prep (low, high intensity) x fertilization (0, 250 lb/ac DAP) x weed control (None, 2 yrs). Primarily Coastal Plain sites in southeast US. P. radiata in Chile, P. taeda in Argentina	1979-81, 2000-04
RW07	Site prep (low, high intensity) x fertilization (0, 250 lb/ac DAP) x weed control (None, 2 yrs). Primarily Coastal Plain sites in southeast US. P. radiata in Chile, P. taeda in Argentina	1979-81, 2000-04
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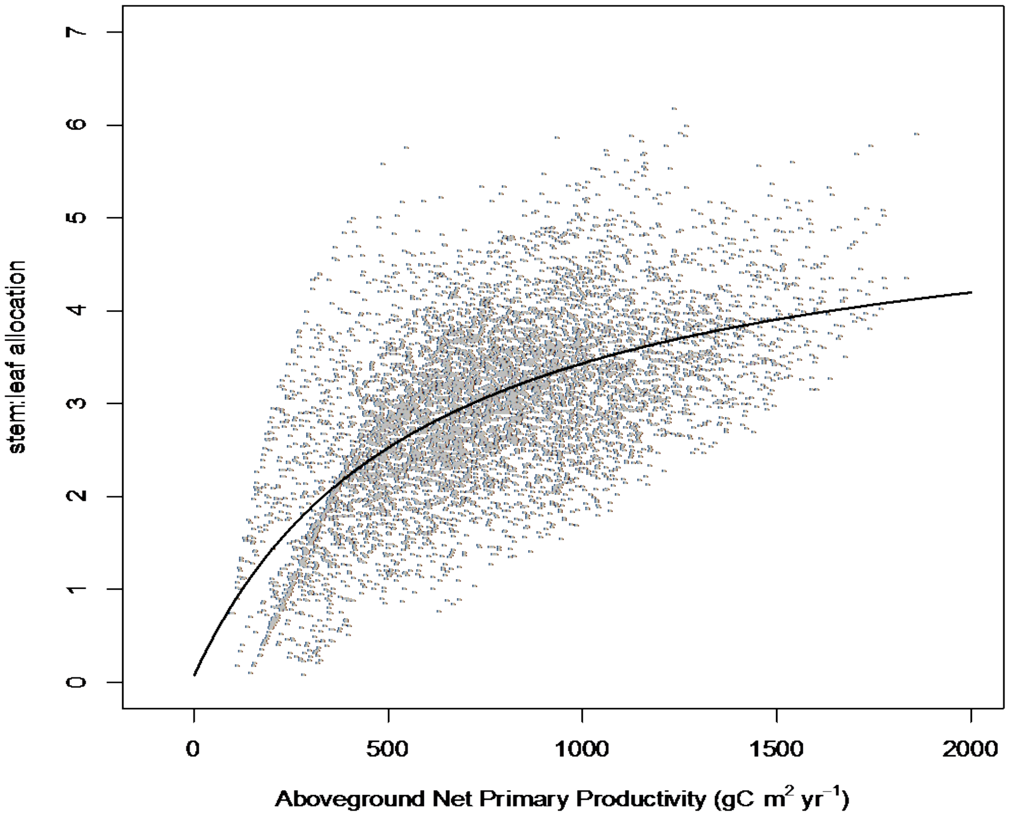
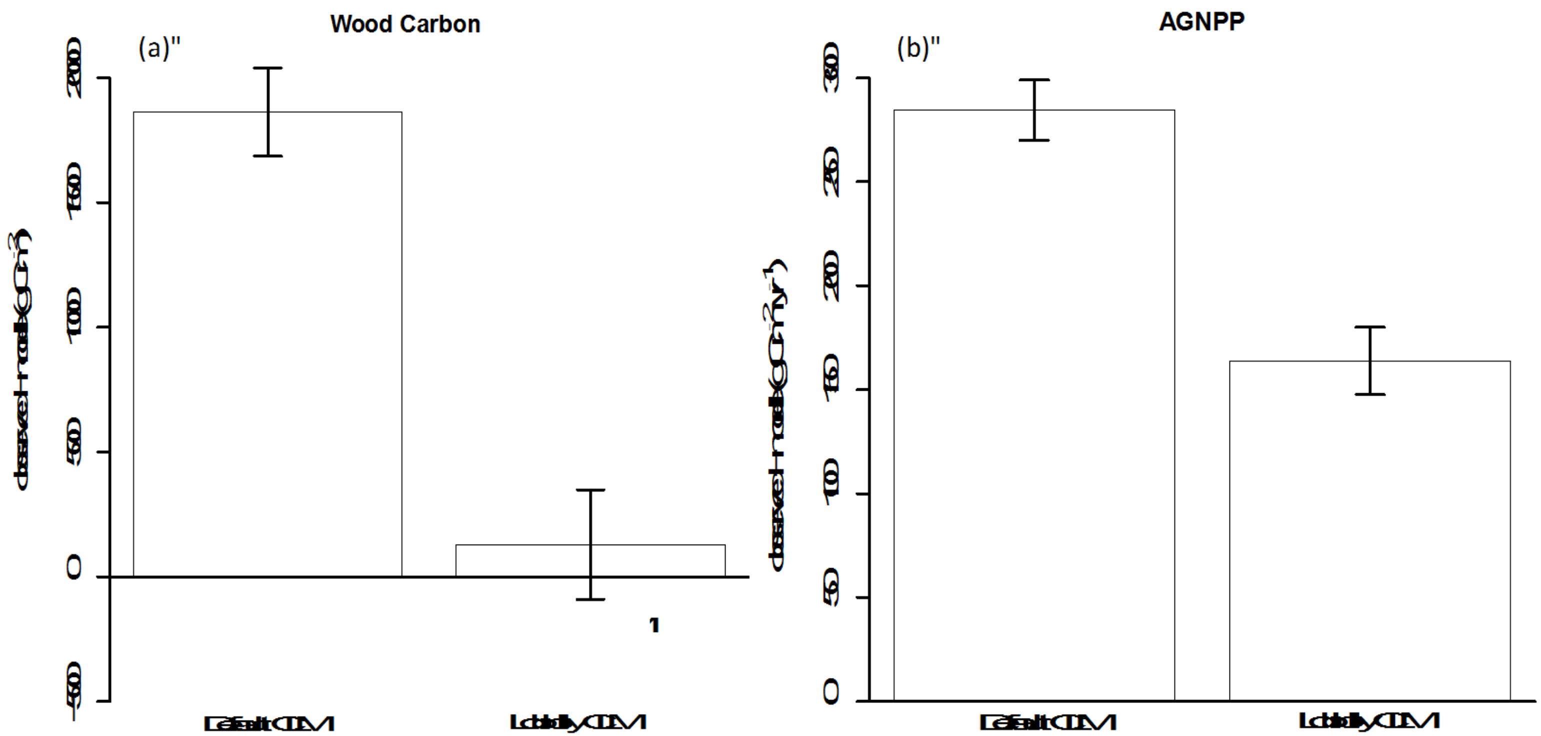
Parameterization of dynamic stem allocation using forest trial data



Including loblolly PFT improved model performance

CLM 4.5 BGC



Forest management

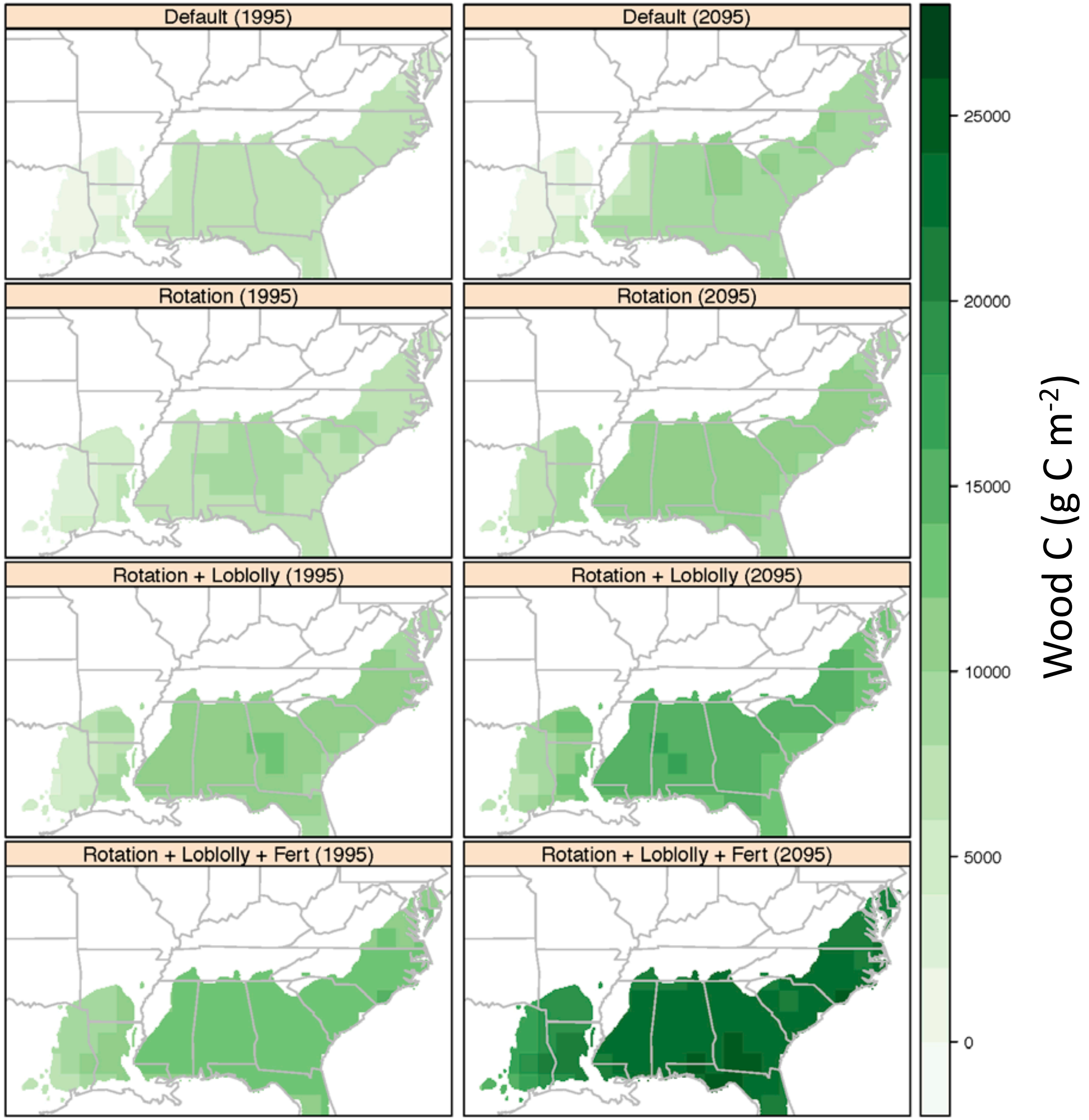
Response of WOOD C between 1995 and 2095 (RCP 8.5 CCSM4 using CLM 4.5 BGC)

- Temperate pine PFT throughout region
- Harvest rate = 1/25 years

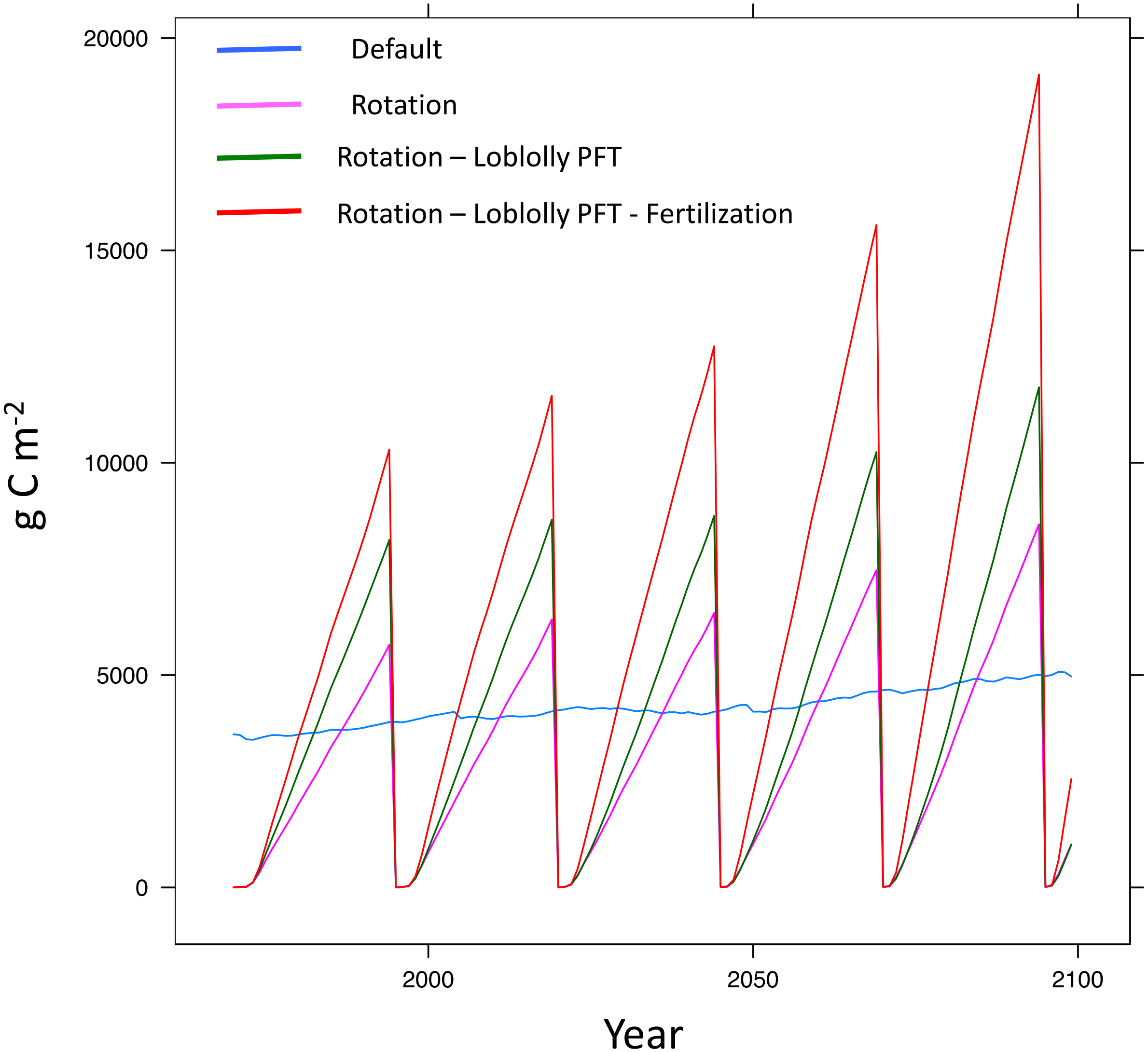
- Temperate pine PFT throughout region
- 100% harvest every 25 years followed by replanting
- 1% mortality rate
- Fire suppression

- Replace temperate pine with loblolly specific PFT
- Otherwise same as previous

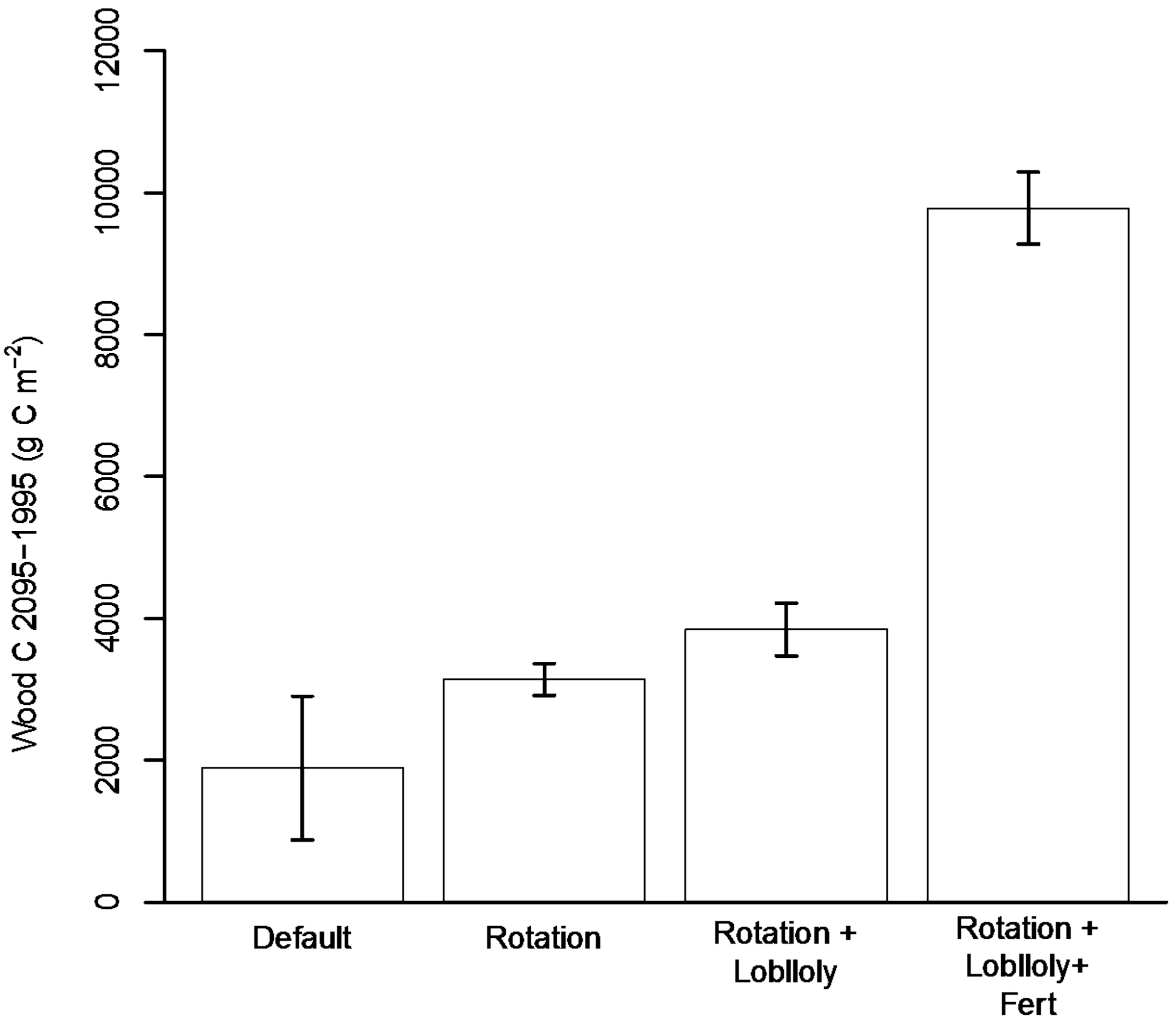
- Nitrogen limitation removed
- Otherwise same as previous



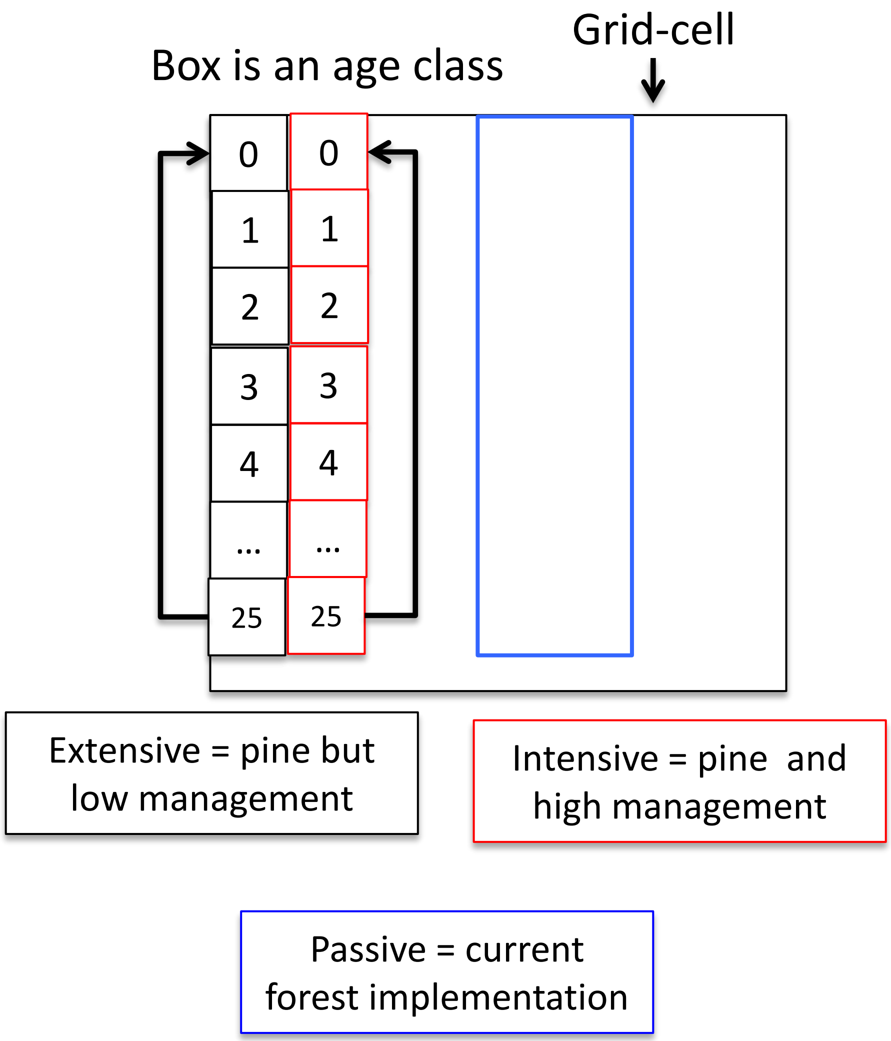
Region-wide mean wood C



Δ Wood C at end of 25 year rotation (2095 – 1995; RCP 8.5)

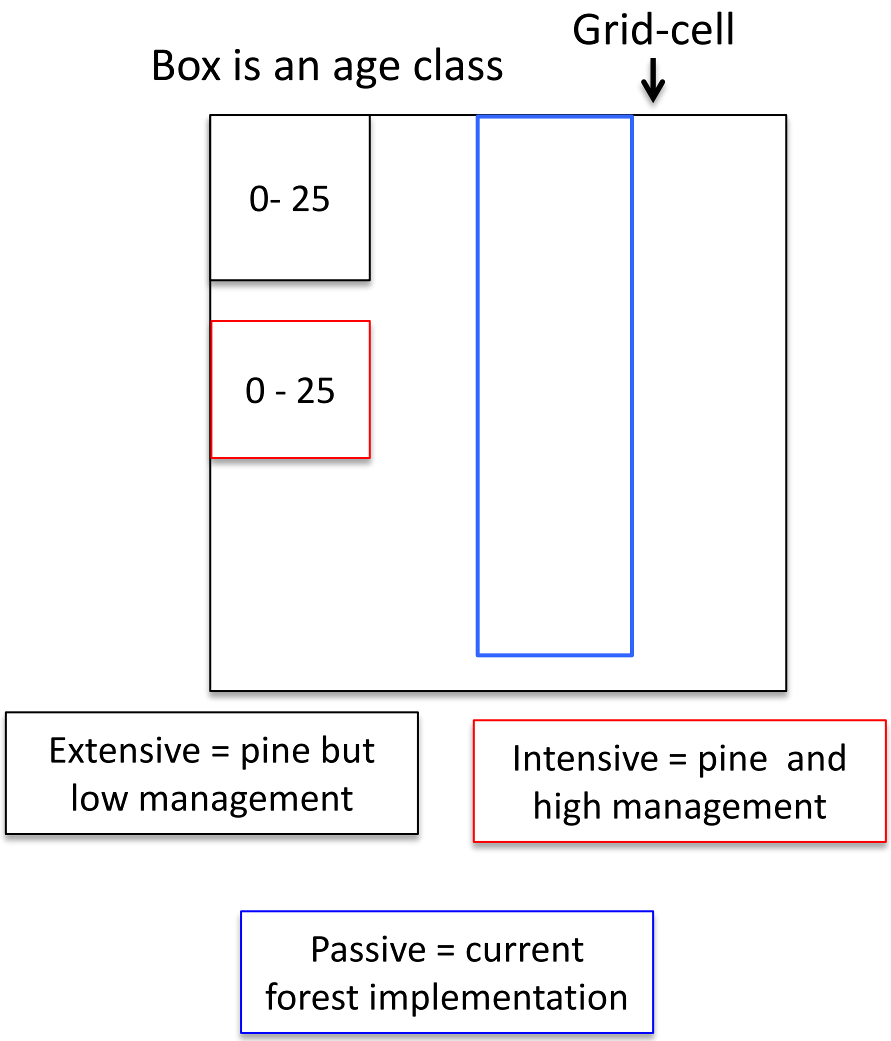


Proposed forest management tiling structure



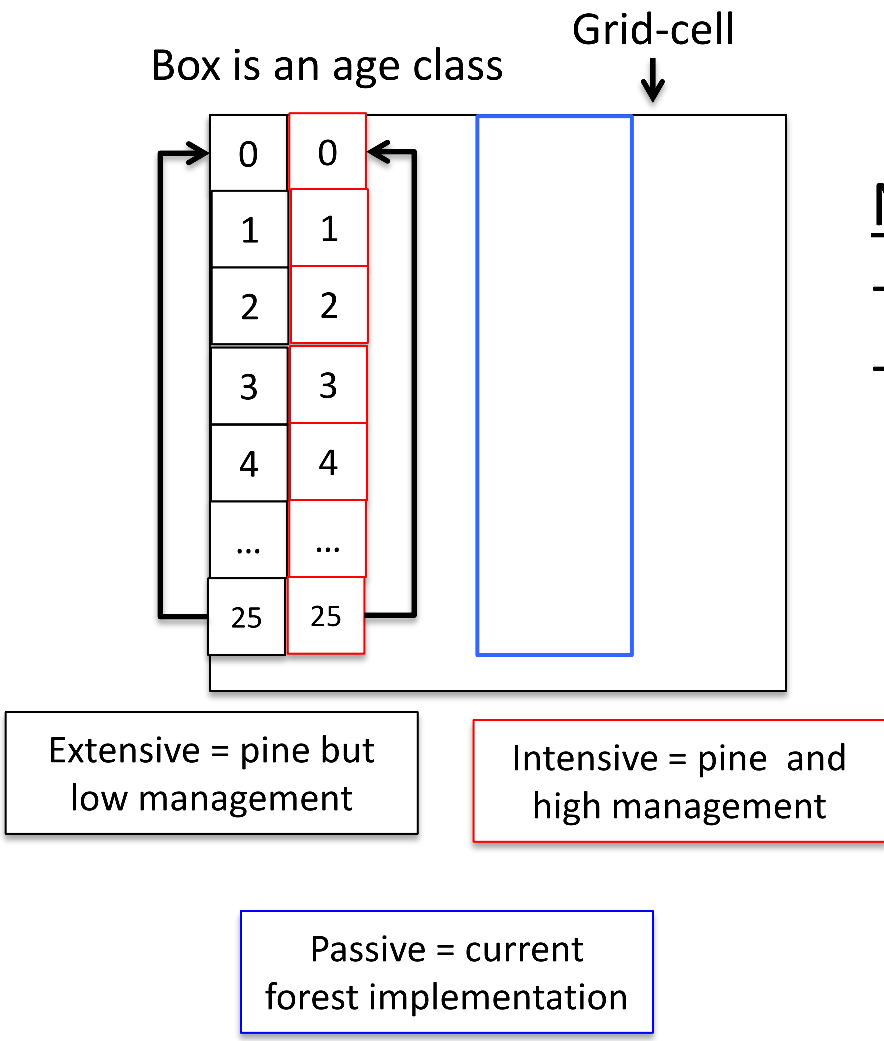
- Build on the existing crop model
- Build on existing dynamic land-units
- Add capacity to transfer vegetation biomass between units
- Harvesting transfers proportion of land-unit to the 0 age class
- Biophysics are calculated for each age class or groups of age classes

Proposed forest management tiling structure



- Alternatively use ED model with extensive and intensive land-units
  - ED would handle the age transitions
  - Share soils across ages
  - Test of ED model using a “white lab rat” system
    - Planting densities

Proposed forest management tiling structure



<u>Needs for CMIP6</u>

- Secondary vs. primary harvest
- Harvest type
  - Industrial roundwood fraction
  - Traditional fuelwood fraction
  - Commercial biofuels fraction

Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185.

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USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

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