US Forest Service Research: Global Change and Air Quality

Focus on Atmospheric CO_2, Air Pollutants and Carbon Sequestration

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Based on Research Presentations by
Richard Birdsey, Yude Pan, and others at the
US Forest Service Northern Research Station

FS Carbon Cycle Research (1)

Flux Towers

Howland, ME
Bartlett, NH
Baltimore, MD
New Jersey
Syracuse, NY
Wisconsin
Marcell, MN
Parker Tract, SC
Niwot Ridge, CO
GLEES, WY

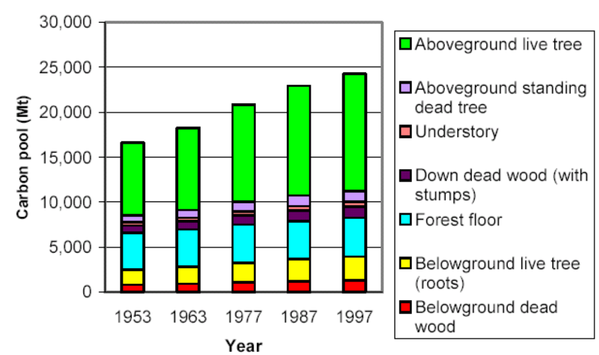
Process Research

FACE Experiment, Rhinelander, Wisconsin

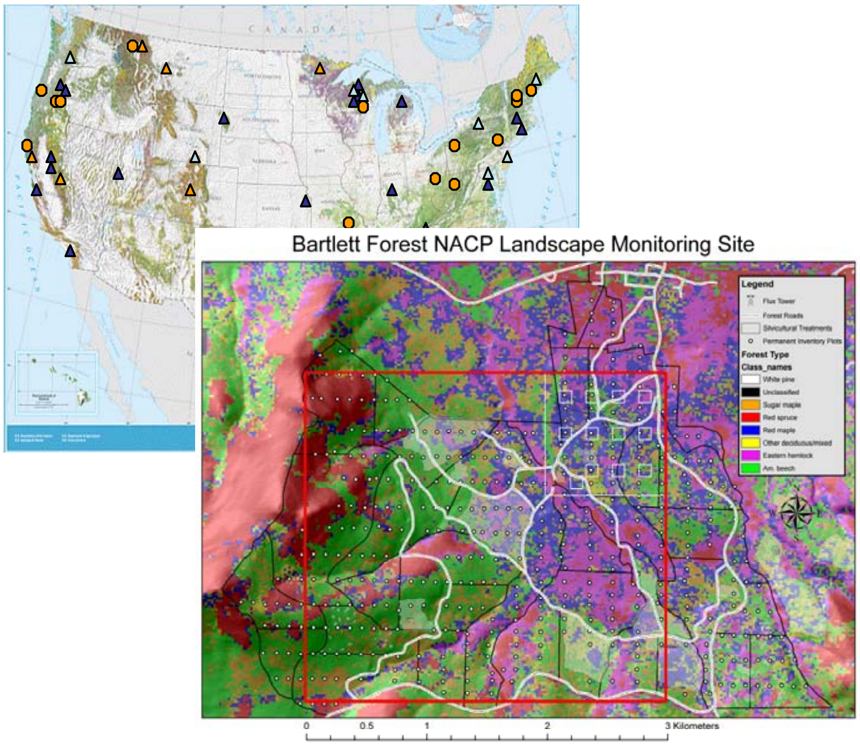
Below-ground process studies

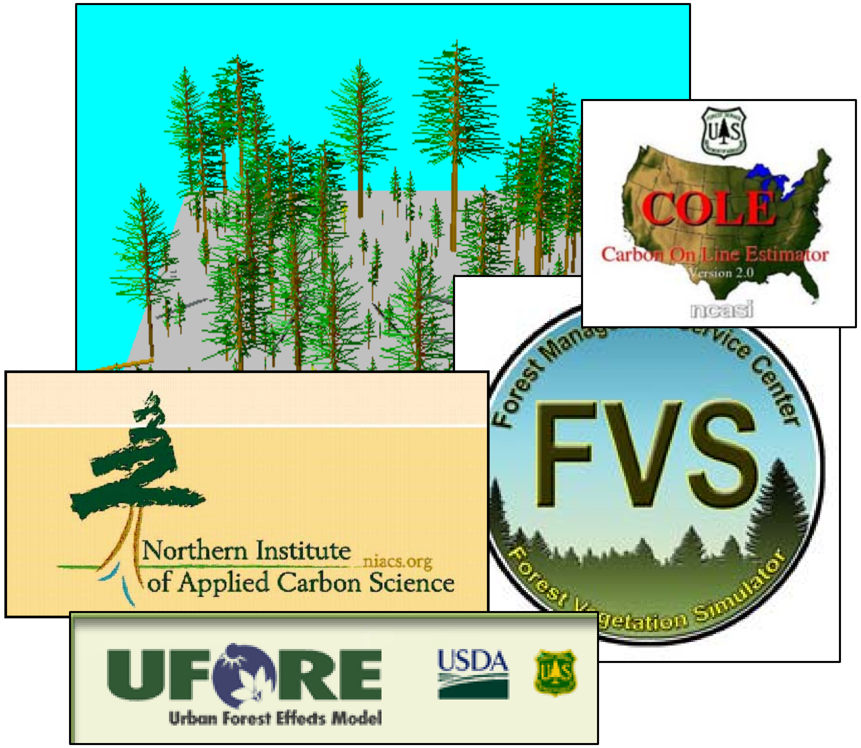
FORCARB

The U.S. Forest Sector Carbon Budget



FS Carbon Cycle Research (2)





North American Carbon Program

Landscape-scale carbon monitoring

Soil carbon initiative

Forest Carbon Management

Accounting rules and guidelines

"Applications" program

The Aspen FACE User Facility

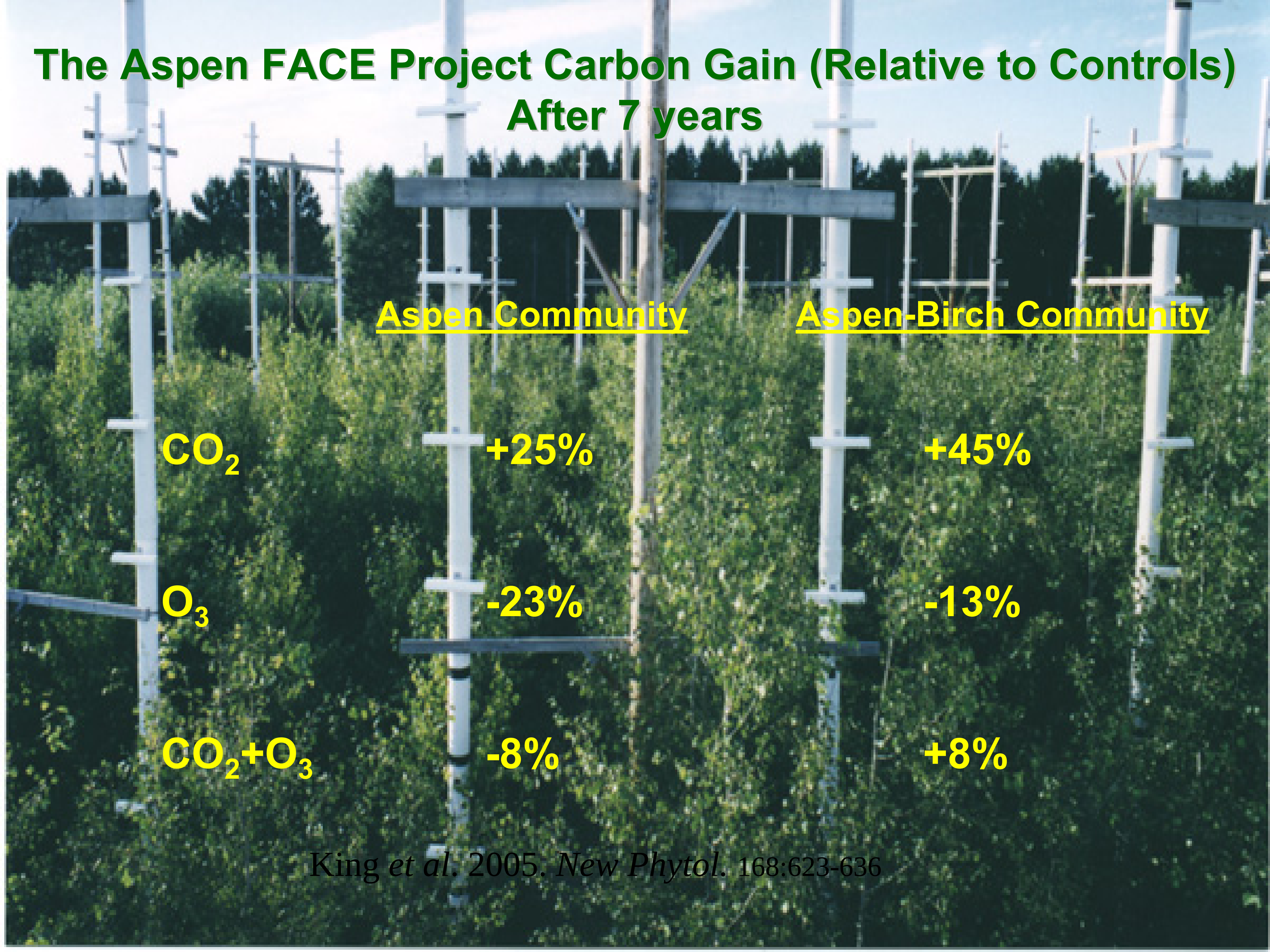
Full Factorial, 3 reps

C, $+CO_2$, $+O_3$, $+CO_2+O_3$

Operation (1998-2005)

CO_2: 360 and 537 ppm

O_3: 38 and 51 ppb



The Aspen FACE Project Carbon Gain (Relative to Controls) After 7 years

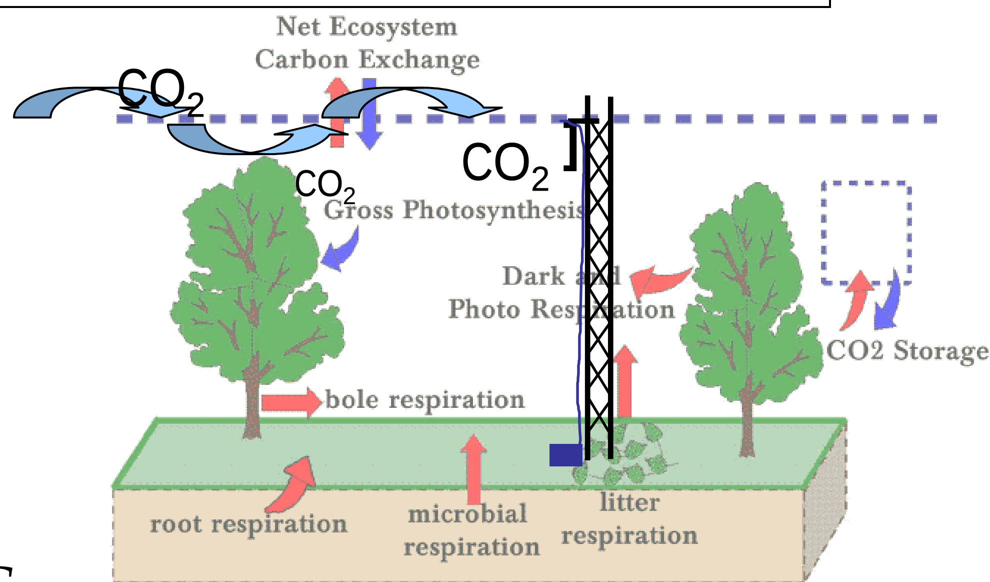
	Aspen Community	Aspen-Birch Community
CO_2	+25%	+45%
O_3	-23%	-13%
CO_2+O_3	-8%	+8%

King *et al.* 2005. *New Phytol.* 168:623-636

Forest Carbon Sequestration

- 2 Approaches to quantifying C sequestration:
  - Measuring changes in stocks over time
  - Direct measurement of fluxes

$$Sequestration = \Delta C_{tree} + \Delta C_{cwd} + \Delta C_{soil}$$

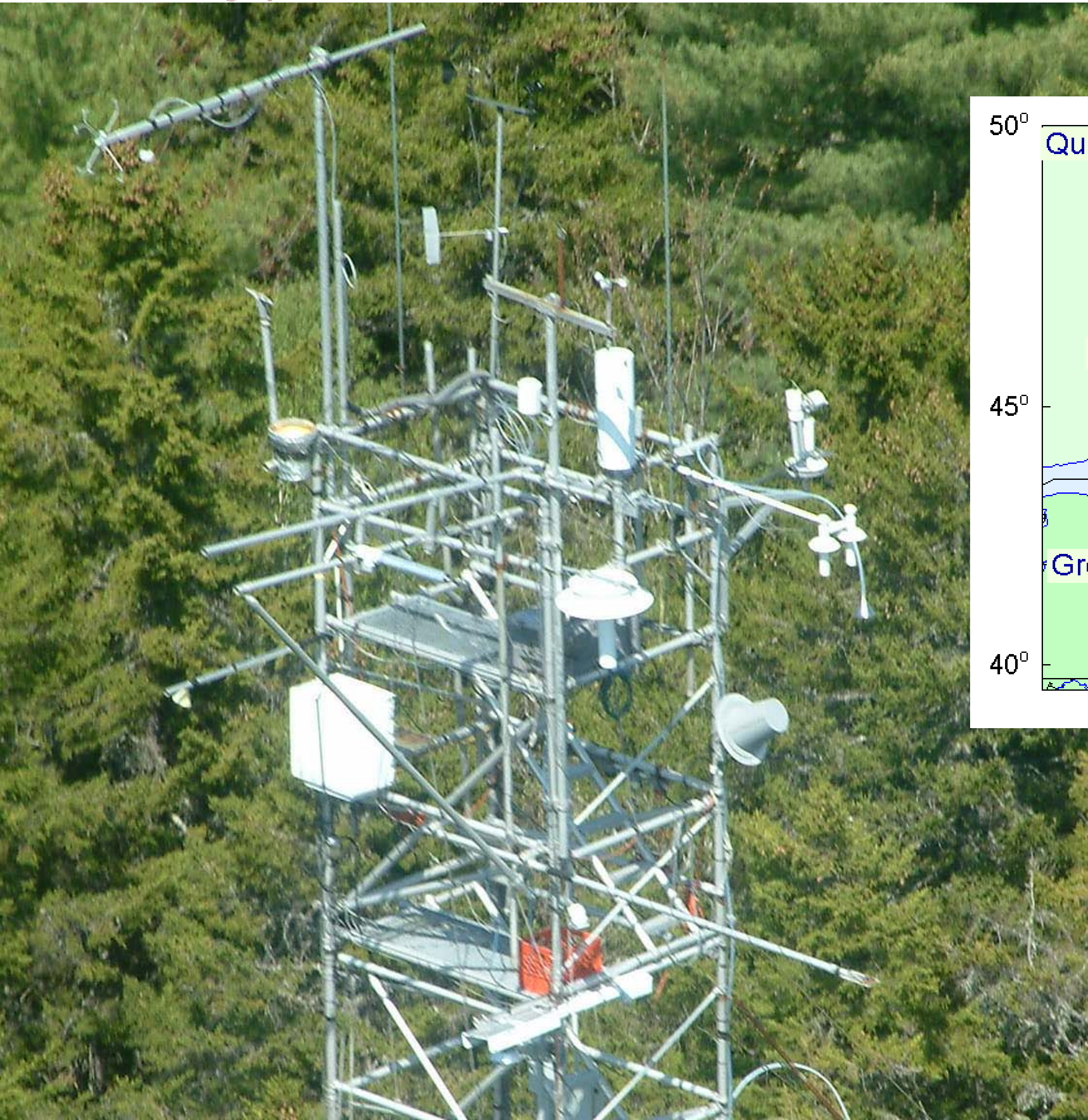


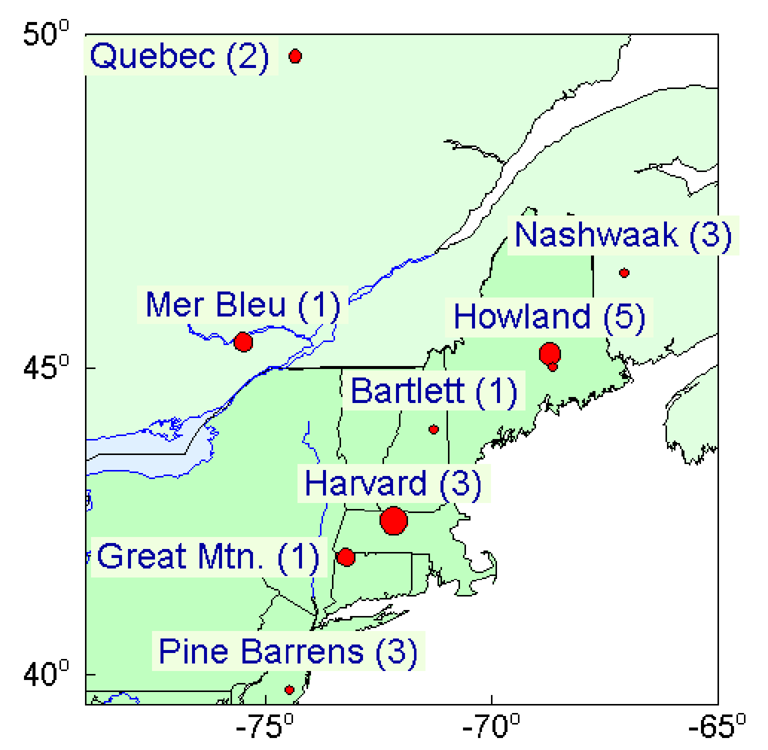
$$Sequestration = \sum \overline{w'c'}$$

USDA Forest Service
Caring for the Land and Serving People

The Woods Hole Research Center

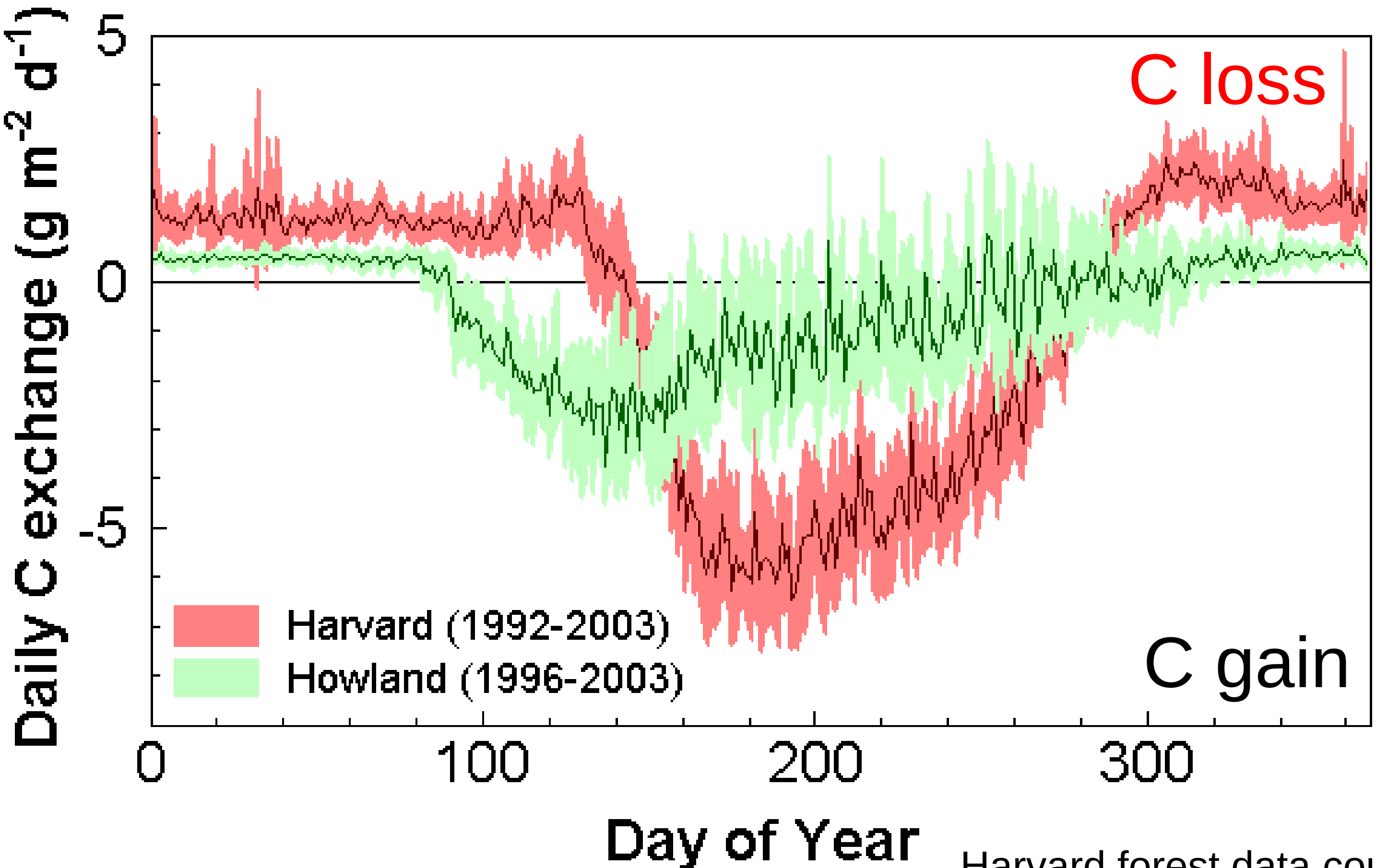
1865 THE UNIVERSITY OF MAINE



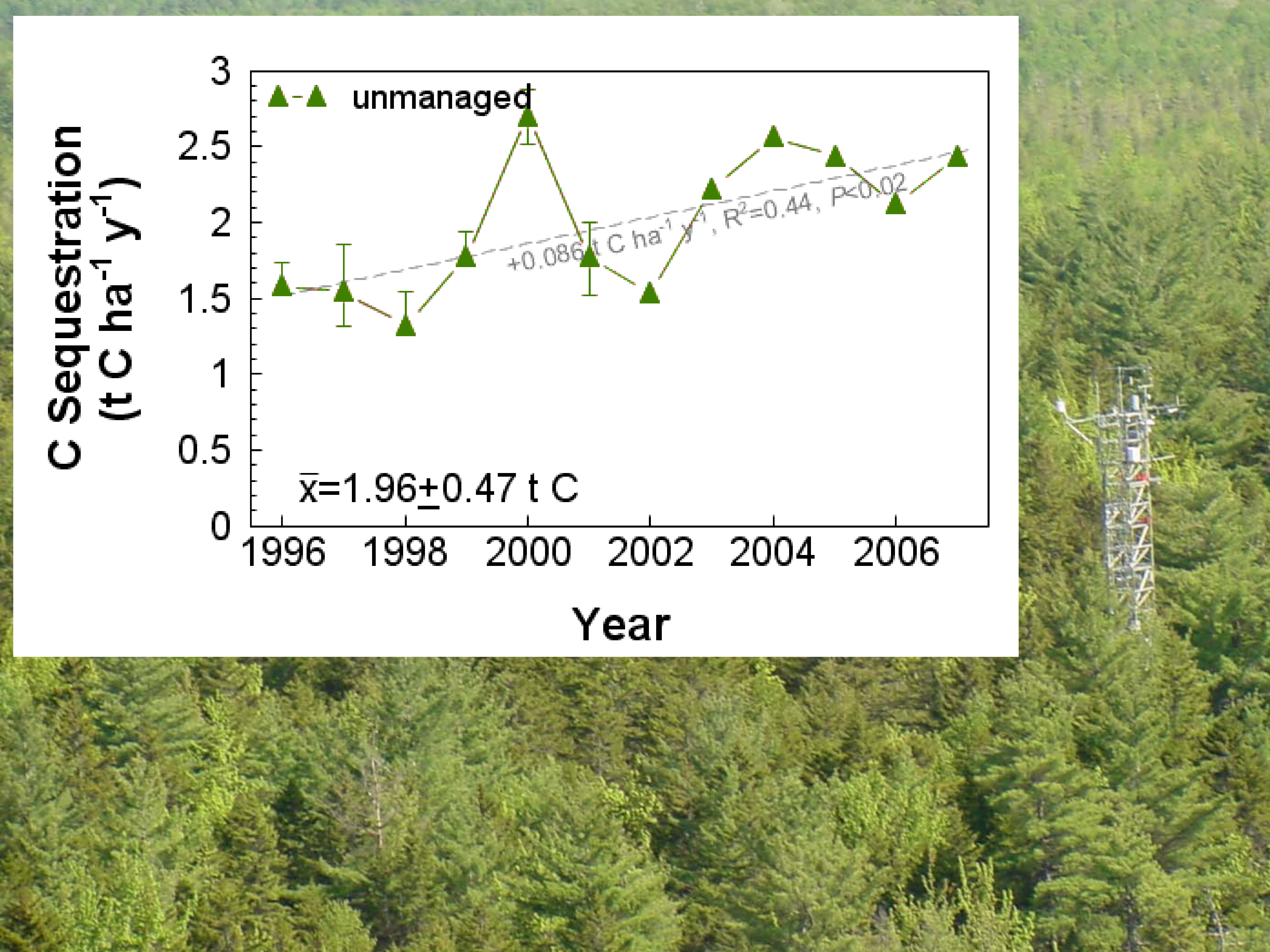


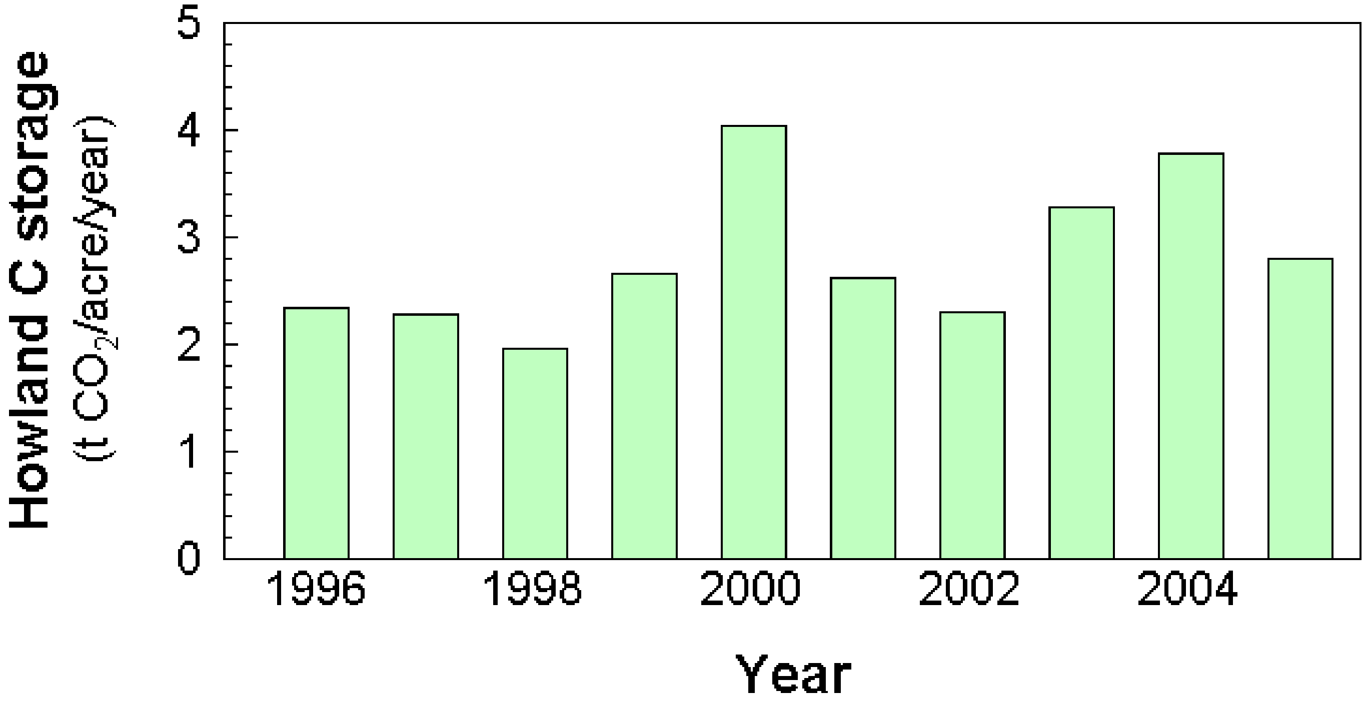
Carbon uptake patterns in deciduous and evergreen NE forests are different:

- Winter respiration higher at Harvard
- Seasonal uptake starts ~50 days earlier at Howland
- Maximum rate of uptake ~2X higher at Harvard

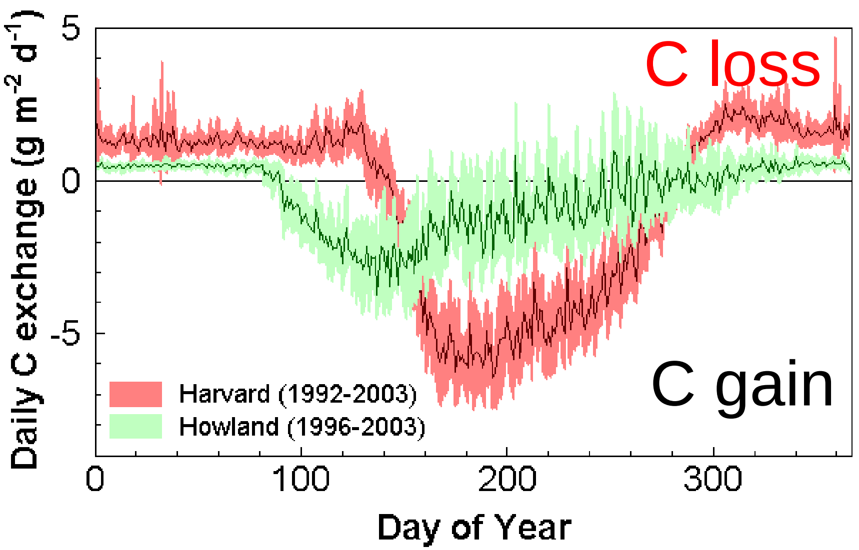


Harvard forest data courtesy S. Wofsy


unmanaged
C Sequestration (t C ha-1 y-1)
3
2.5
2
1.5
1
0.5
0
+0.086 t C ha-1 y-1, R2=0.44, P<0.02
x̄=1.96±0.47 t C
1996
1998
2000
2002
2004
2006
Year

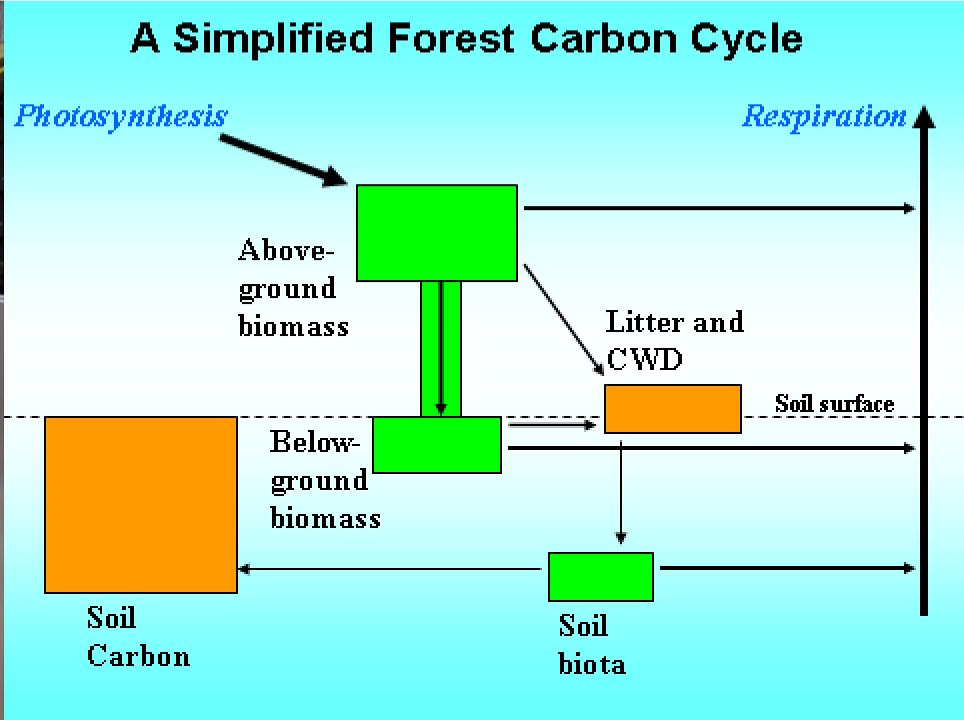


• The Howland old-growth forest is storing almost 3 metric tonnes CO_2 per acre per year; more than 1500 t across the parcel (~$15,000 offset per year)



Below-ground Process Research

- Soil is the frontier of knowledge about climate change and the carbon cycle
- Links between above-ground and below-ground processes not well understood
- Strong implications for management



Elevated CO_2

Increased N deposition

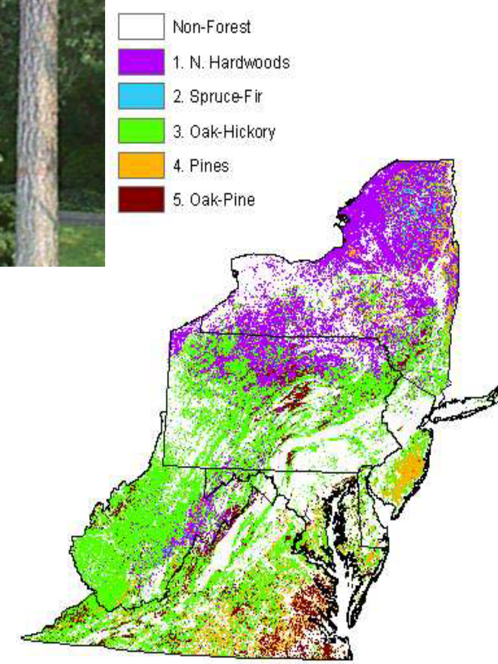
Ozone pollution

N. conifers

N. Hardwood forest

Spruce-fir forests

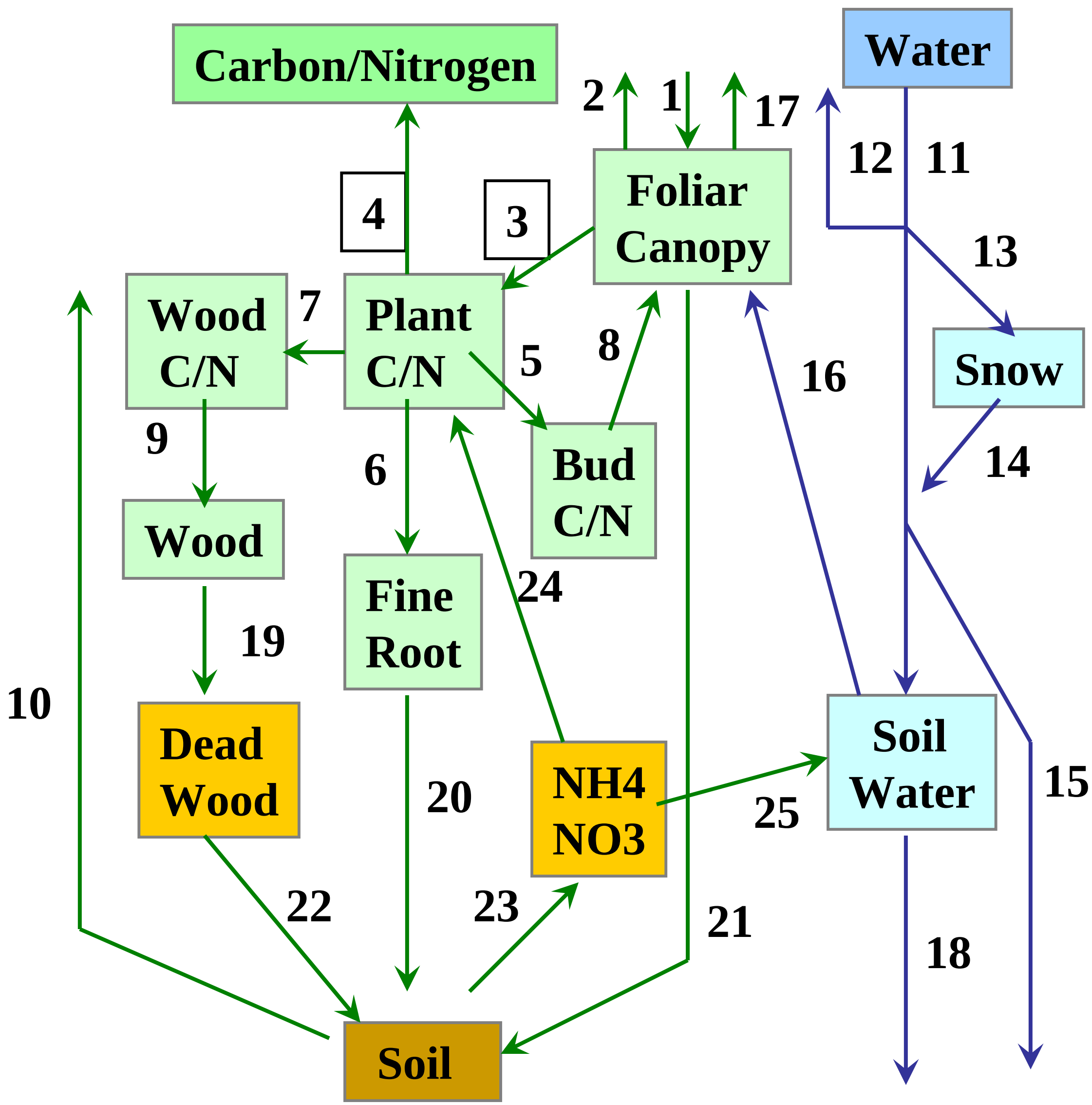
Loblolly pine



Oak-pine

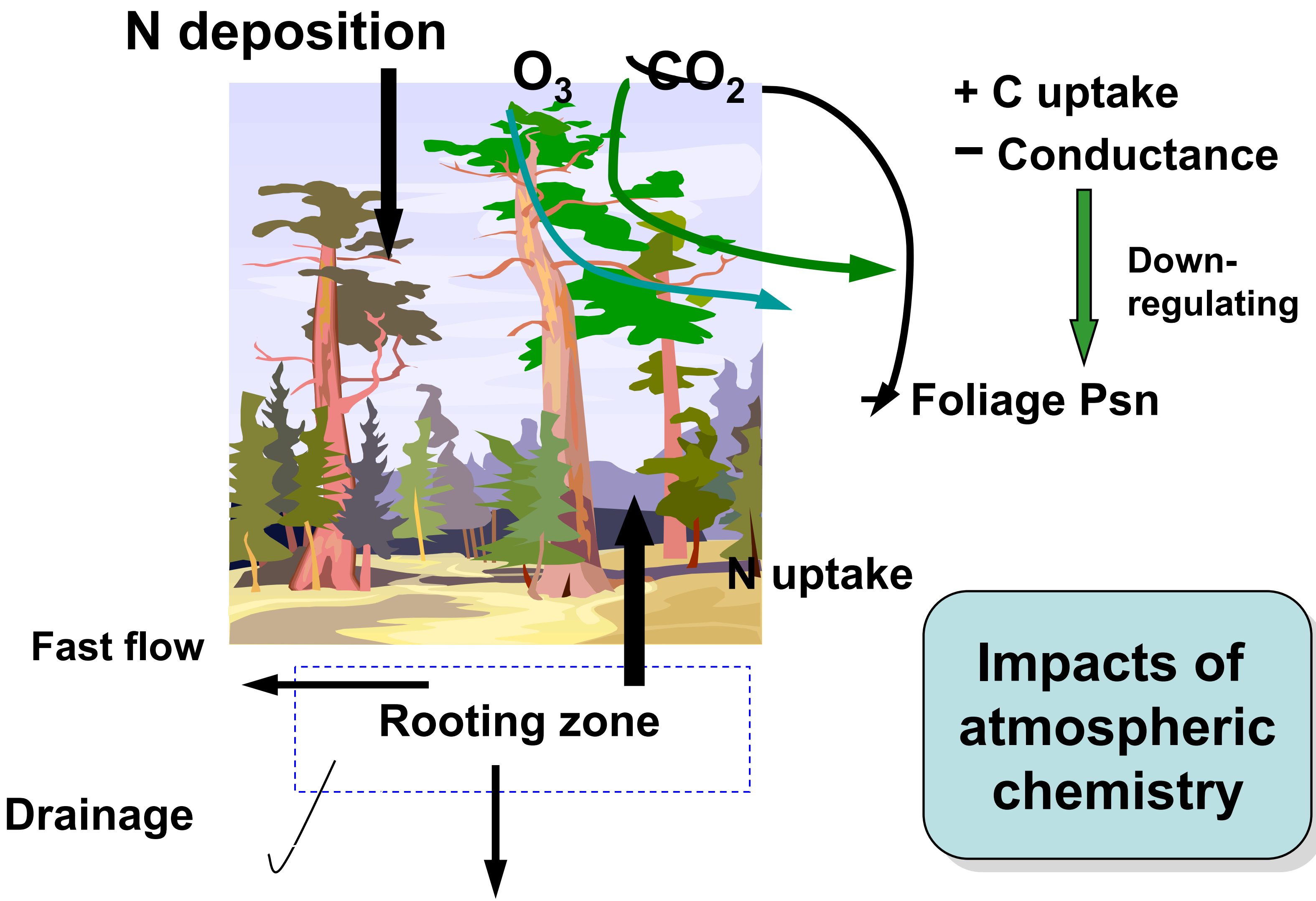
Oak-hickory forest

PnET-CN Model

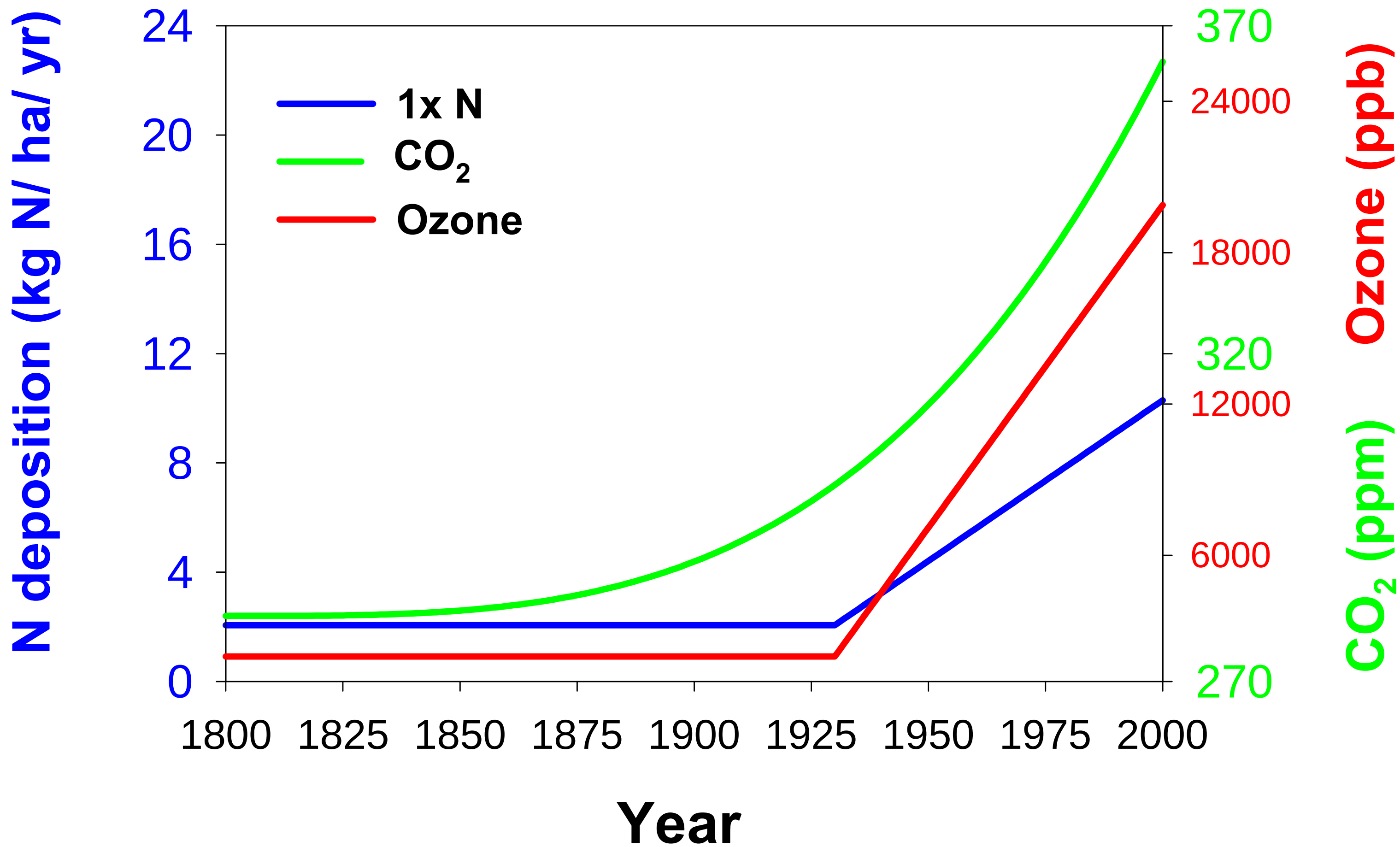


1. Gross photosynthesis
2. Foliar respiration
3. Transfer to mobile C
4. Growth and maintain resp.
5. Allocation to buds
6. Allocation to fine roots
7. Allocation to wood
8. Foliar production
9. Wood production
10. Soil respiration
11. Precipitation
12. Interception
13. Snow-rain partition
14. Snowmelt
15. Fast flow
16. Water uptake
17. Transpiration
18. Drainage
19. Wood litter
20 Root litter
21. Foliar litter
22. Wood decay
23. Mineralization
24. N uptake
25. To soil solution

$$GrossPsn = f(PAR, Temp, VPD, H_2O, N, CO_2, O_3)$$



Scenarios of Increasing Atmopsheric Chemistry

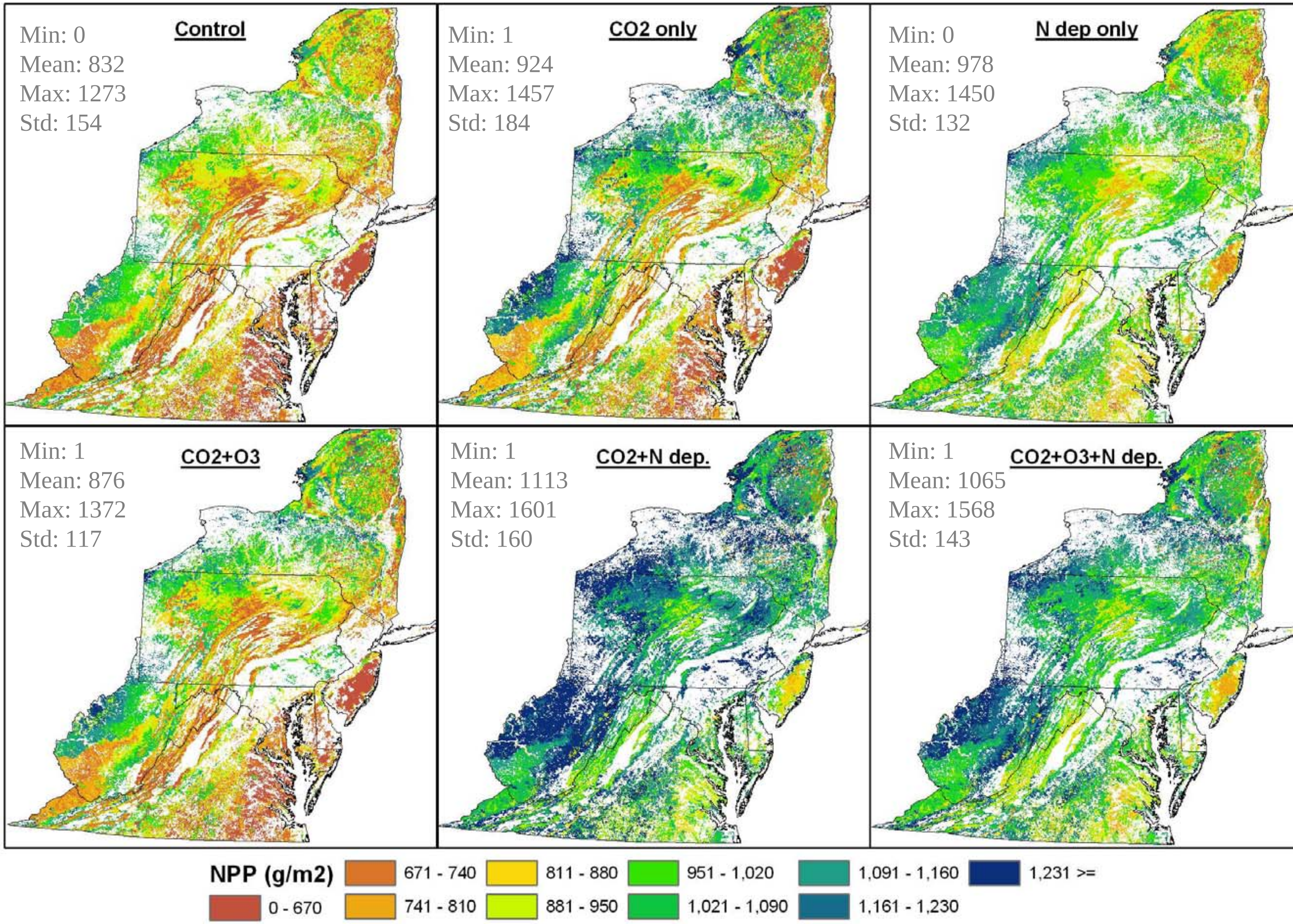


Factorial Model Experiments

	CO_2	O_3	$N_{dep.}$
Run 1: control	○	○	○
Run 2: scenario	●	○	○
Run 3: scenario	○	○	●
Run 4: scenario	●	●	○
Run 5: scenario	●	○	●
Run 6: Scenario	●	●	●

Running years: 1800-2000

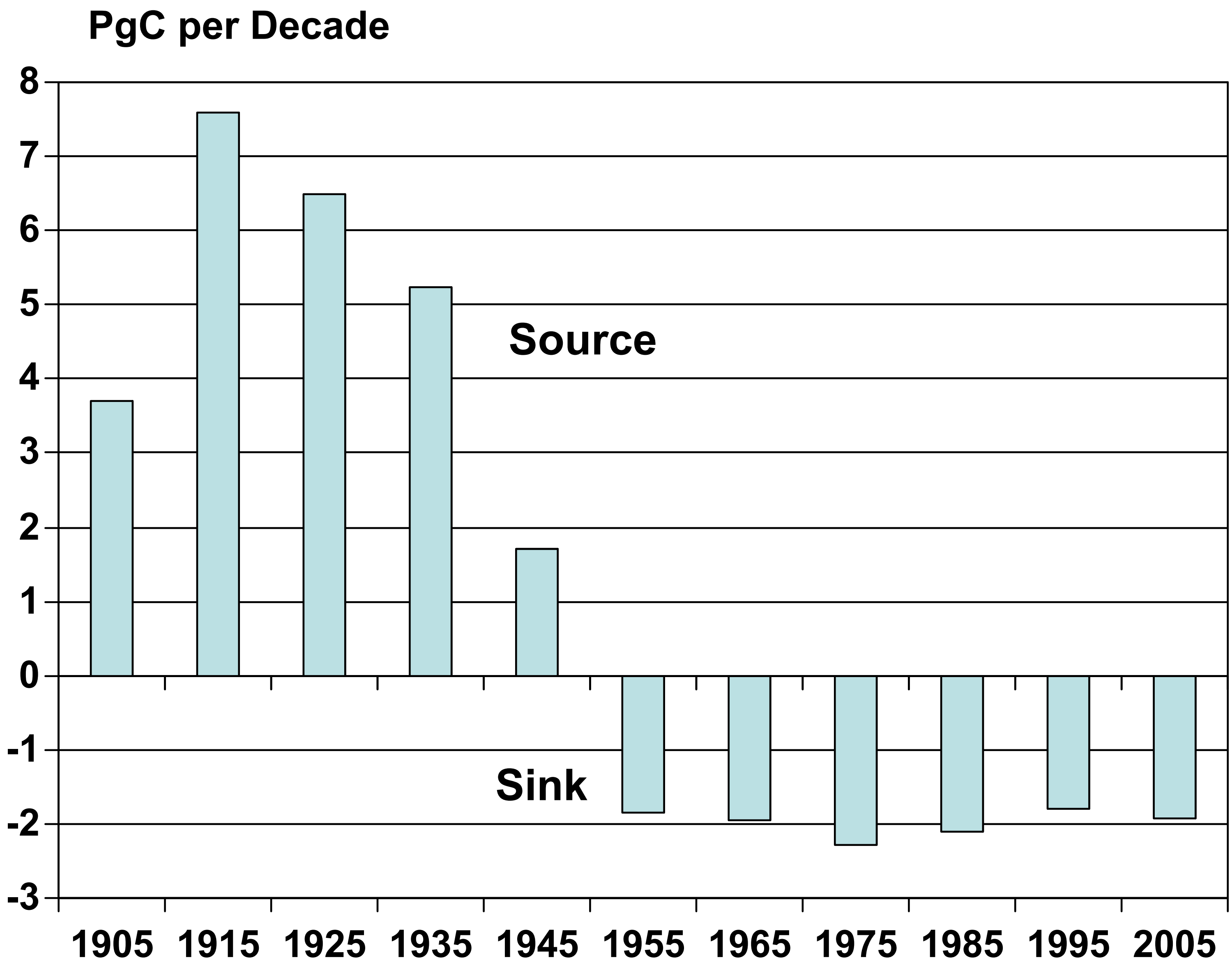
○	**Fixed 280 ppmv**	●	**Ramped up to 366 ppmv**
○	**No ozone input**	●	**Ramped up to current level**
○	**No N input**	●	**Ramped up to current level**



Control
Min: 0
Mean: 832
Max: 1273
Std: 154
CO2 only
Min: 1
Mean: 924
Max: 1457
Std: 184
N dep only
Min: 0
Mean: 978
Max: 1450
Std: 132
CO2+O3
Min: 1
Mean: 876
Max: 1372
Std: 117
CO2+N dep.
Min: 1
Mean: 1113
Max: 1601
Std: 160
CO2+O3+N dep.
Min: 1
Mean: 1065
Max: 1568
Std: 143
NPP (g/m2)
0 - 670
671 - 740
741 - 810
811 - 880
881 - 950
951 - 1,020
1,021 - 1,090
1,091 - 1,160
1,161 - 1,230
1,231 >=

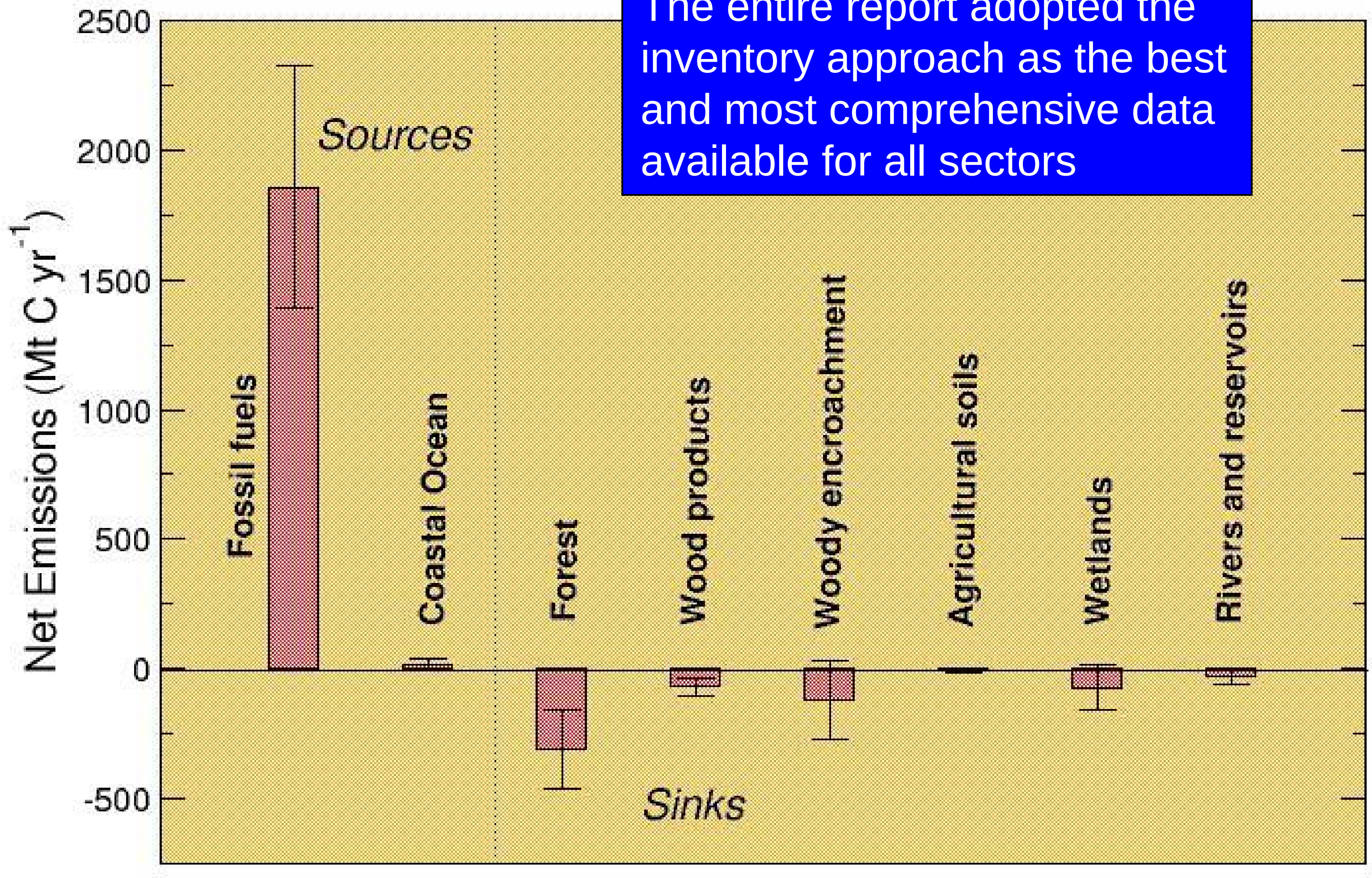
Scenarios	N. Hardwood		Oak-hickory	
	NPP	Biomass	NPP	Biomass
Control	901	224	861	242
N deposition	+ 10%	2%	+ 20%	10%
CO_2	+ 14%	20%	+ 10%	14%
CO_2+O_3	+ 7%	11%	+ 4%	7%
CO_2+ N	+ 31%	28%	+ 38%	30%
CO_2+O_3+ N	+ 22%	18%	+ 29%	21%

Carbon Budget of U.S. Forests and Wood Products by Decade – from FIA



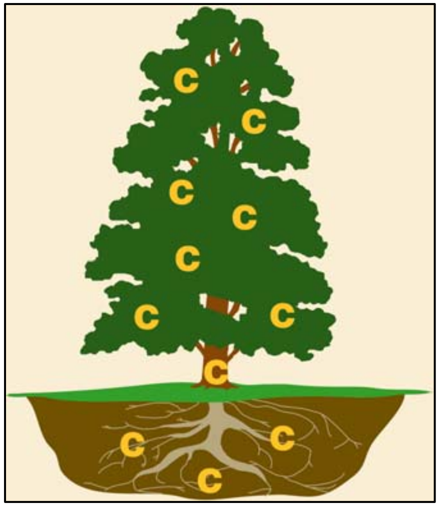
North America is currently a net source of CO_2 with 30% of fossil fuel emissions offset by a net terrestrial sink of 520 ± 260 Mt C yr^{-1}

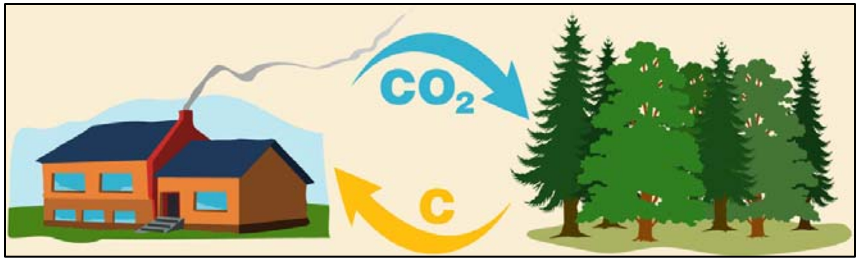
The entire report adopted the inventory approach as the best and most comprehensive data available for all sectors



Potential Additional Role of Forests in Mitigating Greenhouse Gas Emissions

- U.S. forests **currently sequester 700 million tons** of CO_2 per year – 12% of emissions from using fossil fuels
- There is potential to sequester an **additional 1,200 million tons** of CO_2 per year
- Forest biomass and products may reduce CO_2 by **600 million more tons** per year





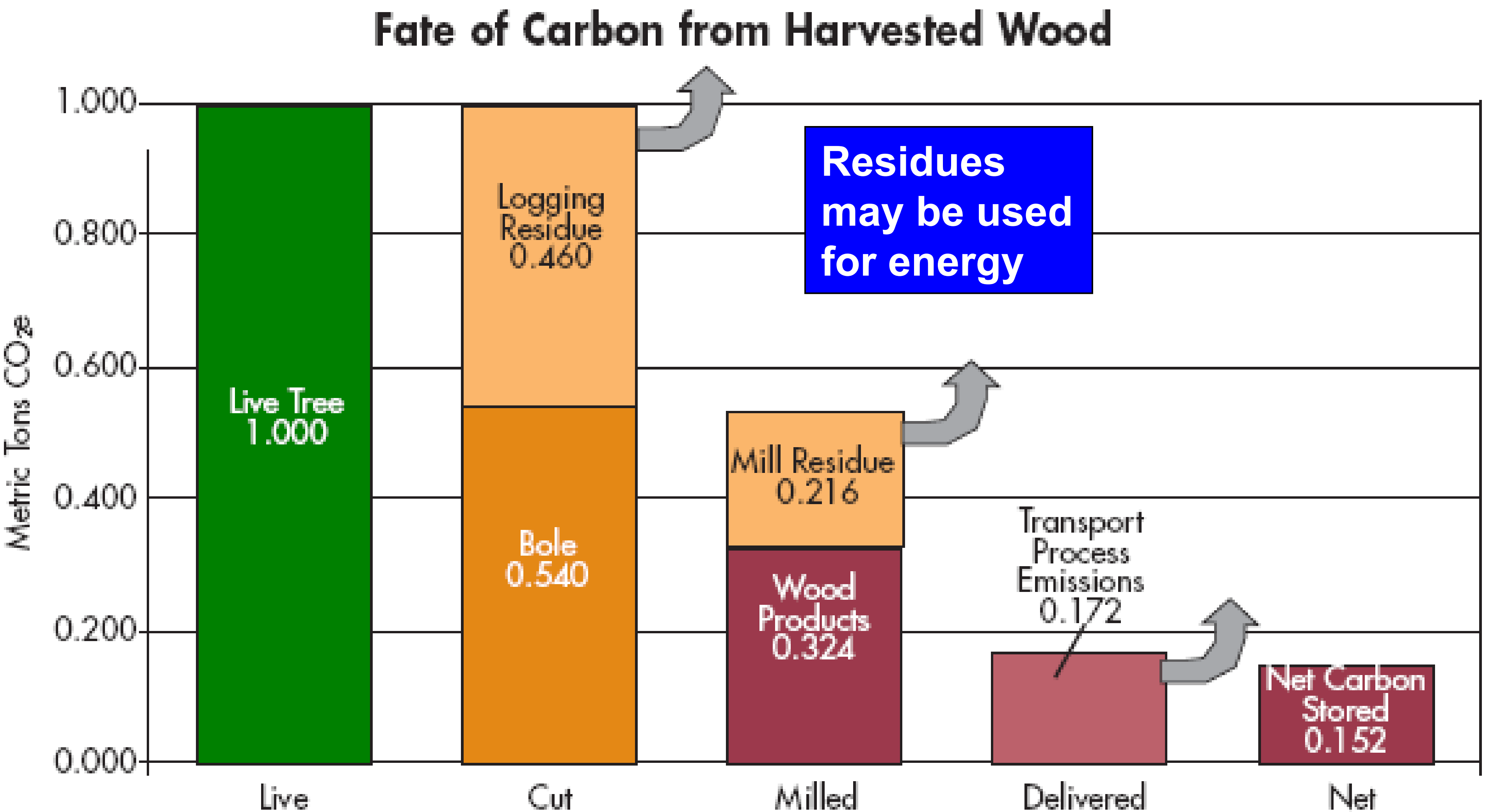
Activities to Increase Carbon Sequestration or Reduce Emissions

- Avoiding deforestation
- Afforestation
- Mine land reclamation
- Forest restoration
- Improved forest management
- Short-rotation biomass energy plantations
- Substitute wood for other materials
- Agroforestry
- Urban forestry

Under the Healthy Forest Restoration Act, carbon stocks are being reduced over large areas of the Western U.S.

Greenhouse Gas Balance of Wood Production

(adapted from Ingerson 2007)



Data from Smith et al. 2006 and Gower et al. 2006.

Thank You !