Forest Carbon Management in the United States: 1600-2100

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Forest Carbon Management: 1600-2100

- **Extraction and Deforestation: 1600-1900**
- **Harvest, Regrowth, Management: 1900-2000**
- **Global Stewardship: The 21st Century**
  - Managing the atmosphere
  - Forest sector
  - Forestry activities
  - Forest practices

Themes:
- Inventory systems
- Technologies and practices
- Decision support
Extraction and Deforestation: 1600-1900

From Eric Sloan
Drain on the Sawtimber Stand, 1650-1925
Billion Board Feet per Decade

“A long struggle against growth was the experience of hundreds of thousands of settlers in timberland.”

From an unpublished Forest Service Report by R.V. Reynolds and A.H. Pierson
Washington, DC, 1941
Carbon Emissions from Drain on the Sawtimber Stand, 1630-1930

Emissions

Sequestration

MtC/yr

Million acres of forest land

Total cut, billion board feet per decade

1600 1700 1800 1900

1600 1700 1800 1900

1200

1000

800

600

400

200

0

1600 1700 1800 1900

1600 1700 1800 1900
Carbon Emissions from Drain on the Sawtimber Stand, 1630-1930

MtC/yr

Forest Ecosystem

Emissions

Net Change

Sequestration

Wood Products

1600 1700 1800 1900
Harvest, Regrowth, Management: 1900-2000

Old-growth stands provide the major part of the timber cut on the Pacific coast.

Much of the recent gain in forest land area is attributable to reforestation of abandoned farmland.

Over half of the forest land in the Southeast is grazed by domestic livestock.
Average Area of Land Affected by Wildfire, 1916-1997

Uncontrolled fire in the 1930’s and early 1940’s in the South kept pine land poorly stocked
Example of Forest Type Changes: Southern U.S.
Example of Forest Structure Changes: Northern Rockies
Forest Ecosystem Carbon Pools for Forest Land of the Conterminous U.S. (soil C excluded)

Heath and Smith 2003: National Report on Sustainable Forests
Carbon Sequestration on United States Timberland and in Wood Products, 1953-2001

Excludes soil C, reserved forest land, other forest land

From Heath and Smith 2003; Skog 2003

38% decline in ecosystem carbon sequestration
Carbon Emissions from Drain on the Sawtimber Stand, and Sequestration from Regrowth, 1630-2000
Global Stewardship: 2000-2100

- Managing the atmosphere
- Forest sector
- Forestry activities
- Forest practices
- Technology
The U.S. Leads:
- Worldwide emissions of carbon dioxide
- Investment in climate change research ($2 billion in 2004)

Since 1880: 30% Increase to 370 ppmv

Atmospheric CO₂ Concentration

BIG CO₂ EMITTERS
Emissions from fuel combustion, 2002

<table>
<thead>
<tr>
<th>Country</th>
<th>Million tonnes</th>
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<tbody>
<tr>
<td>USA</td>
<td>2000</td>
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<tr>
<td>EU25</td>
<td>600</td>
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<td>100</td>
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<tr>
<td>India</td>
<td>100</td>
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<tr>
<td>Other</td>
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</table>
21st Century Challenge: Stabilize Atmospheric CO\textsubscript{2} Concentrations

From Pacala and Socolow in Nature 2004

Business-as-usual emissions scenario

Emissions scenario to achieve stabilization at 500 ppm CO\textsubscript{2}

Options to achieve stabilization

• Biomass energy
• Forestry
• Agriculture
• Other options
How Big is the Forest Sector Stabilization Wedge?

Carbon Budget of the U.S. Forest Sector, 1700-2100
The Forest Sector Stabilization Wedge

Activities:
- Afforestation
- Mine land reclamation
- Forest restoration
- Agroforestry
- Forest management
- Biomass energy
- Forest preservation
- Wood products
- Urban forestry

Example Practices:
- Thinning
- Rotation length
- Residue management
- Species/genotypes

Technology
The National Plan for Reducing Greenhouse Gases

- In 2002, the President directed Secretaries of Energy and Agriculture to revise guidelines for reporting
  - Originally authorized in the 1992 Energy Policy Act section 1605(b)
- Program is voluntary
- Registered reductions may lead to transferable credits
- Take into account emerging domestic and international approaches
- Develop new targeted incentives for carbon sequestration and greenhouse gas reductions
- Research and development
Continuing National and International Debate on Climate Policy Options

- Market mechanisms
  - Chicago climate exchange
  - European Union exchange
- U.S., regional, and State
  - Action plans
  - Greenhouse gas registries
- DOE “Regional Partnerships” and “Climate Vision”
- EPA “Climate Leaders” program
- ISO greenhouse gas standards
- Kyoto treaty mechanisms
  - National GHG reduction targets
  - Clean Development Mechanism
  - Joint Implementation projects
  - Emissions trading
Will a market approach work for managing CO₂?

• European cap and trade system modeled after successful U.S. emissions trading scheme

• U.S. approach involves voluntary participation with incentives

From BBC News 2/16/05
Potential Role of Forests in Mitigating Greenhouse Gas Emissions

- U.S. forests remove carbon dioxide from the atmosphere
  - 200 million tons C per year (10% of U.S. fossil fuel emissions)
- It is feasible to increase the rate of carbon sequestration in forests...
  - Plant more trees
  - Maintain healthy forests
  - Manage productivity
  - Residue management
- ...and forest products
  - Biomass energy
  - Use more wood

From Heath and Smith
Forest Ecosystems, Practices and Technology

From Host
Disturbances Affecting U.S. Forests, 1990’s

- Insects and disease
- Wildfire
- Partial cut harvest
- Clearcut harvest
- Timber stand improvement
- Plantation establishment
- Grazing
- Deforestation
- Afforestation

Birdsey and Lewis 2003
How Carbon Stocks Change After Disturbance is Critical

- **Organic Soil**
  - Boreal
  - Temperate
  - Tropical

- **Mineral Soil**
  - Boreal
  - Temperate
  - Tropical

- **Coarse Woody Debris**
  - Boreal
  - Temperate
  - Tropical

**Living Biomass**

- Temperate & Tropical
- Boreal

**Total Ecosystem C**

- Temperate & Tropical
- Boreal

*Pregitzer and Euskirchen 2004*

*Biome synthesis*
The Role of Ecosystem Respiration

General steady state, but with some interannual variability due to climate

Pregitzer and Euskirchen 2004
Biome synthesis
Generalizations Regarding Carbon Cycling and Storage in Forests

- Net C accumulation depends on time since disturbance
- NPP and NEP are strongly correlated except in younger forests
- Microbial respiration (Rh) declines with age
- Reducing the pulse of microbial respiration after disturbance will increase NEP
- Factors that regulate decomposition of CWD are the same as those that regulate Rh
Some Promising Forestry Technology for Increasing Carbon Sequestration

- Nutrient management
- Residue management and utilization
- Thinning and utilization of thinnings
- Low-impact harvesting
- Optimum rotation length
- Species/genotype selection
- Forest biotechnology
Critical Research Needs for Forest Carbon Management (1)

• Socioeconomic issues
  – Quantifying the forestry opportunity
  – Relative benefits of sequestration vs. emissions reduction
  – Integrating carbon management with other objectives
  – Land-use policies and drivers of land-use change

• Forest carbon accounting and measurement issues
  – Life cycle analysis including fossil fuel emissions associated with management and use
  – Additionality, leakage, and avoided emissions
  – Reducing cost of measurement and monitoring
Critical Research Needs for Forest Carbon Management (2)

- **Carbon management technology**
  - Reduce respiration emissions from forests
    - Utilization of logging residues
    - Low-impact harvesting
  - Reduce fossil fuel emissions from operations and manufacturing
    - Efficiency in harvesting technology and biomass transportation
    - Efficiency in manufacturing operations
  - Mechanistic studies of C fluxes along chronosequences
  - Well-designed field experiments to develop practices for maximizing NEP following harvest
  - Improve efficiencies of carbon management technologies

- **Technology transfer**
  - Decision support tools
  - Demonstration projects
Carbon Management Questions and Concerns

- Are forest carbon sinks permanent?
- How much CO₂ is emitted from wildfire?
- How to account for natural disturbance?
- Changes in forest soil carbon?
- Accounting for wood products

- Who will participate?
- Will the market accept forest carbon credits?
- Estimate “additionality”?

Wildfire in the U.S.

3 million hectares burned in 2000 ~ 65 MTC
Simplified Decision Support “Roadmap” for Carbon Management

Extensive data:
- FIA/FHM
- Remote Sensing

Landscape data:
- Biometrics
- Remote sensing

Intensive data:
- CO₂ flux
- Meteorology
- Field experiments

Ecoregion models:
- FORCARB
- CASA
- LANDIS
- PnET
- TEM

Tree/stand models:
- FVS
- AMORPHYS
- UFORE
- CORRIM

Decision support:
- COLE
- NIACS
- CQUEST
- Growout
- GHG inventory

Carbon manager

Scale up

Experimentation/Monitoring → Modeling → Decision support
Outlook for Forest Carbon Management

Themes:
- Inventory of baseline and wedge
- What technologies and practices?
- Decision support

Goal: additional 100-200 MtC/yr
Final Thoughts

- **Sustainability** – are recommendations for forest carbon management complementary with resource sustainability?
- **Ecosystem Services** – how does forest carbon management enhance or detract from other ecosystem services such as water and biodiversity?