BIOMASS BOILERS, GREENHOUSE GASES, AND CLIMATE CHANGE:

Everything You Ever Wanted to Know About Carbon Emissions from your Biomass Boiler but were afraid to Ask!

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BIOMASS BOILERS, GREENHOUSE GASES, AND CLIMATE CHANGE:

The GHG Implications of Using Forest Biomass for Energy

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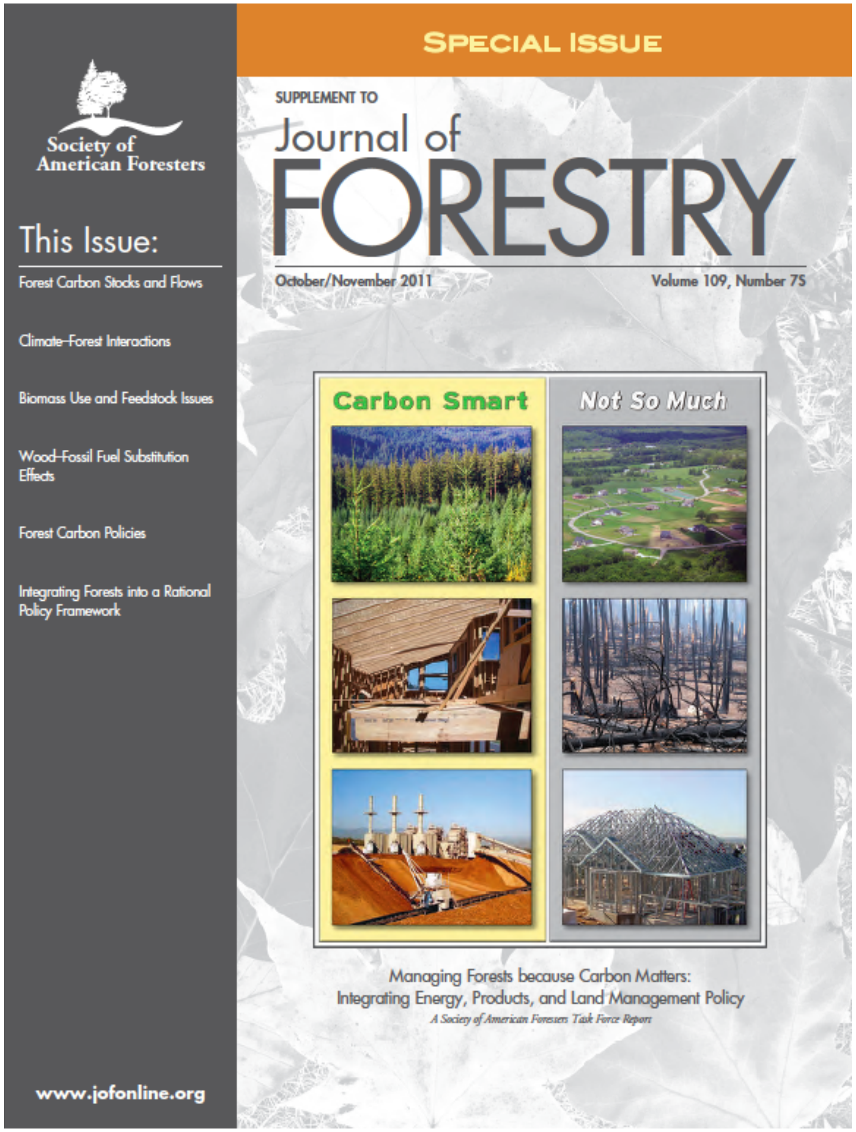
Forests and Climate Change



A Team Approach

The Society of American Foresters'
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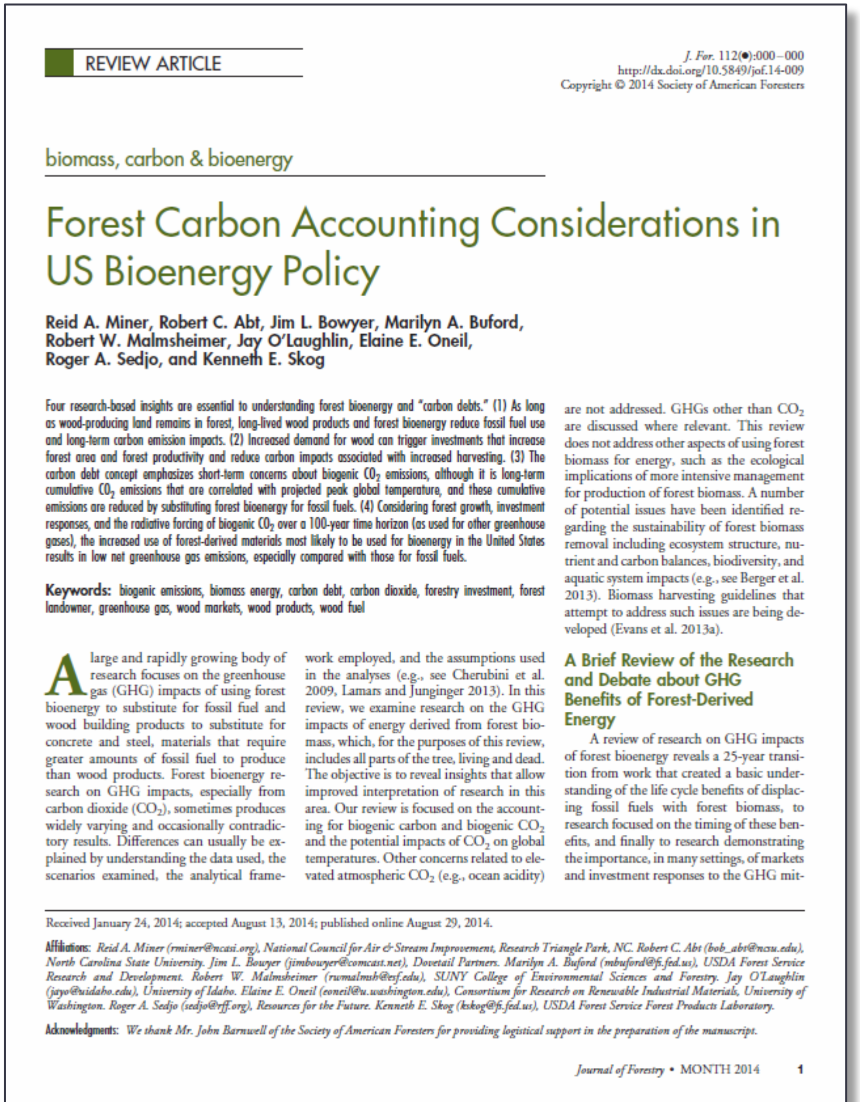
Sources and Outcome



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biomass, carbon & bioenergy

Forest Carbon Accounting Considerations in US Bioenergy Policy

Reid A. Miner, Robert C. Abt, Jim L. Bowyer, Marilyn A. Buford, Robert W. Malmsheimer, Jay O'Laughlin, Elaine E. Oneil, Roger A. Sedjo, and Kenneth E. Skog

Four research-based insights are essential to understanding forest bioenergy and "carbon debts." (1) As long as wood-producing land remains in forest, long-lived wood products and forest bioenergy reduce fossil fuel use and long-term carbon emission impacts. (2) Increased demand for wood can trigger investments that increase forest area and forest productivity and reduce carbon impacts associated with increased harvesting. (3) The carbon debt concept emphasizes short-term concerns about biogenic CO_2 emissions, although it is long-term cumulative CO_2 emissions that are correlated with projected peak global temperature, and these cumulative emissions are reduced by substituting forest bioenergy for fossil fuels. (4) Considering forest growth, investment responses, and the radiative forcing of biogenic CO_2 over a 100-year time horizon (as used for other greenhouse gases), the increased use of forest-derived materials most likely to be used for bioenergy in the United States results in low net greenhouse gas emissions, especially compared with those for fossil fuels.

Keywords: biogenic emissions, biomass energy, carbon debt, carbon dioxide, forestry investment, forest landowner, greenhouse gas, wood markets, wood products, wood fuel

A large and rapidly growing body of research focuses on the greenhouse gas (GHG) impacts of using forest bioenergy to substitute for fossil fuel and wood building products to substitute for concrete and steel, materials that require greater amounts of fossil fuel to produce than wood products. Forest bioenergy research on GHG impacts, especially from carbon dioxide (CO_2), sometimes produces widely varying and occasionally contradictory results. Differences can usually be explained by understanding the data used, the scenarios examined, the analytical framework employed, and the assumptions used in the analyses (e.g., see Cherubini et al. 2009, Lamars and Junginger 2013). In this review, we examine research on the GHG impacts of energy derived from forest biomass, which, for the purposes of this review, includes all parts of the tree, living and dead. The objective is to reveal insights that allow improved interpretation of research in this area. Our review is focused on the accounting for biogenic carbon and biogenic CO_2 and the potential impacts of CO_2 on global temperatures. Other concerns related to elevated atmospheric CO_2 (e.g., ocean acidity) are not addressed. GHGs other than CO_2 are discussed where relevant. This review does not address other aspects of using forest biomass for energy, such as the ecological implications of more intensive management for production of forest biomass. A number of potential issues have been identified regarding the sustainability of forest biomass removal including ecosystem structure, nutrient and carbon balances, biodiversity, and aquatic system impacts (e.g., see Berger et al. 2013). Biomass harvesting guidelines that attempt to address such issues are being developed (Evans et al. 2013a).

A Brief Review of the Research and Debate about GHG Benefits of Forest-Derived Energy

A review of research on GHG impacts of forest bioenergy reveals a 25-year transition from work that created a basic understanding of the life cycle benefits of displacing fossil fuels with forest biomass, to research focused on the timing of these benefits, and finally to research demonstrating the importance, in many settings, of markets and investment responses to the GHG mit-

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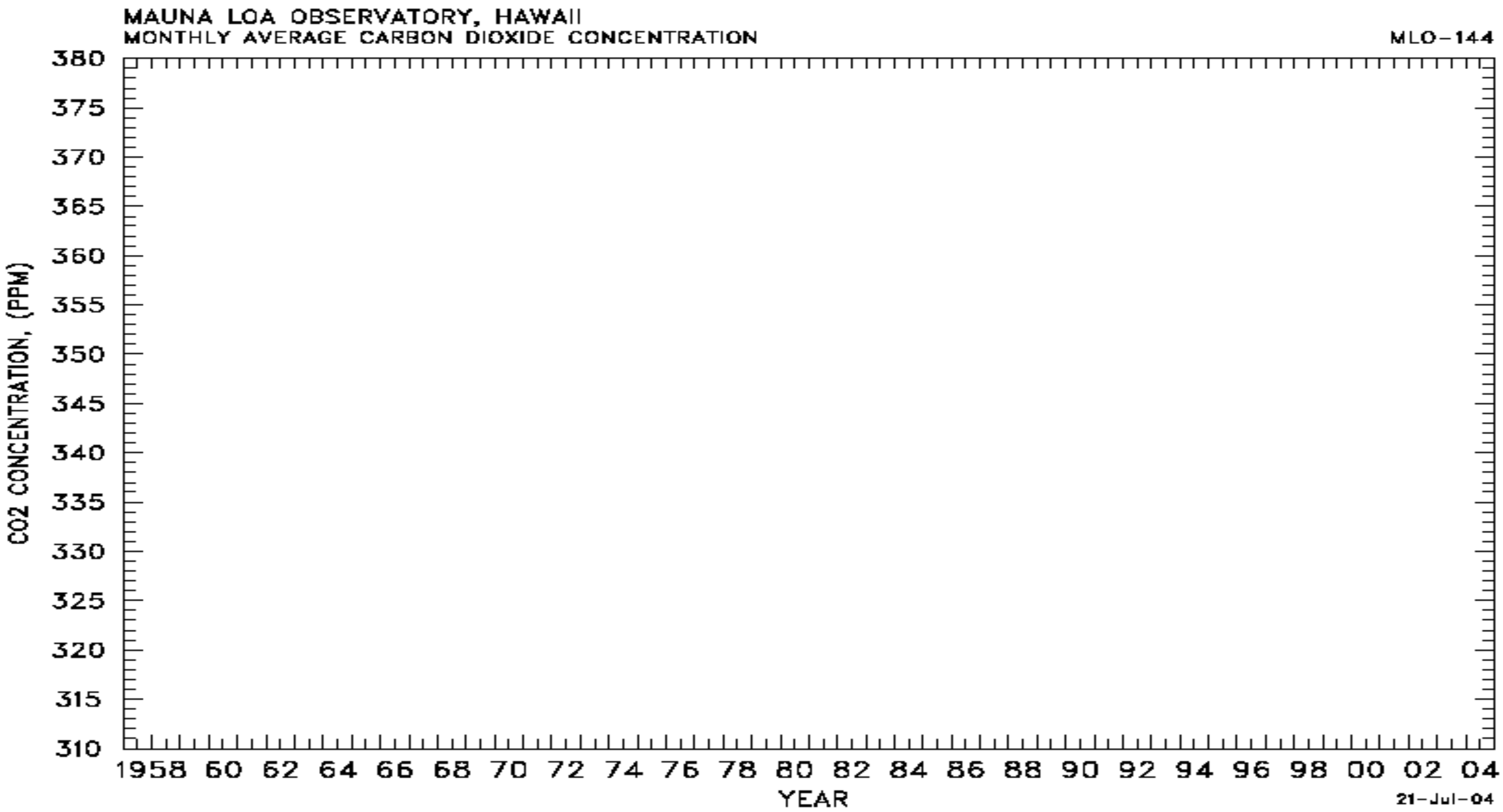
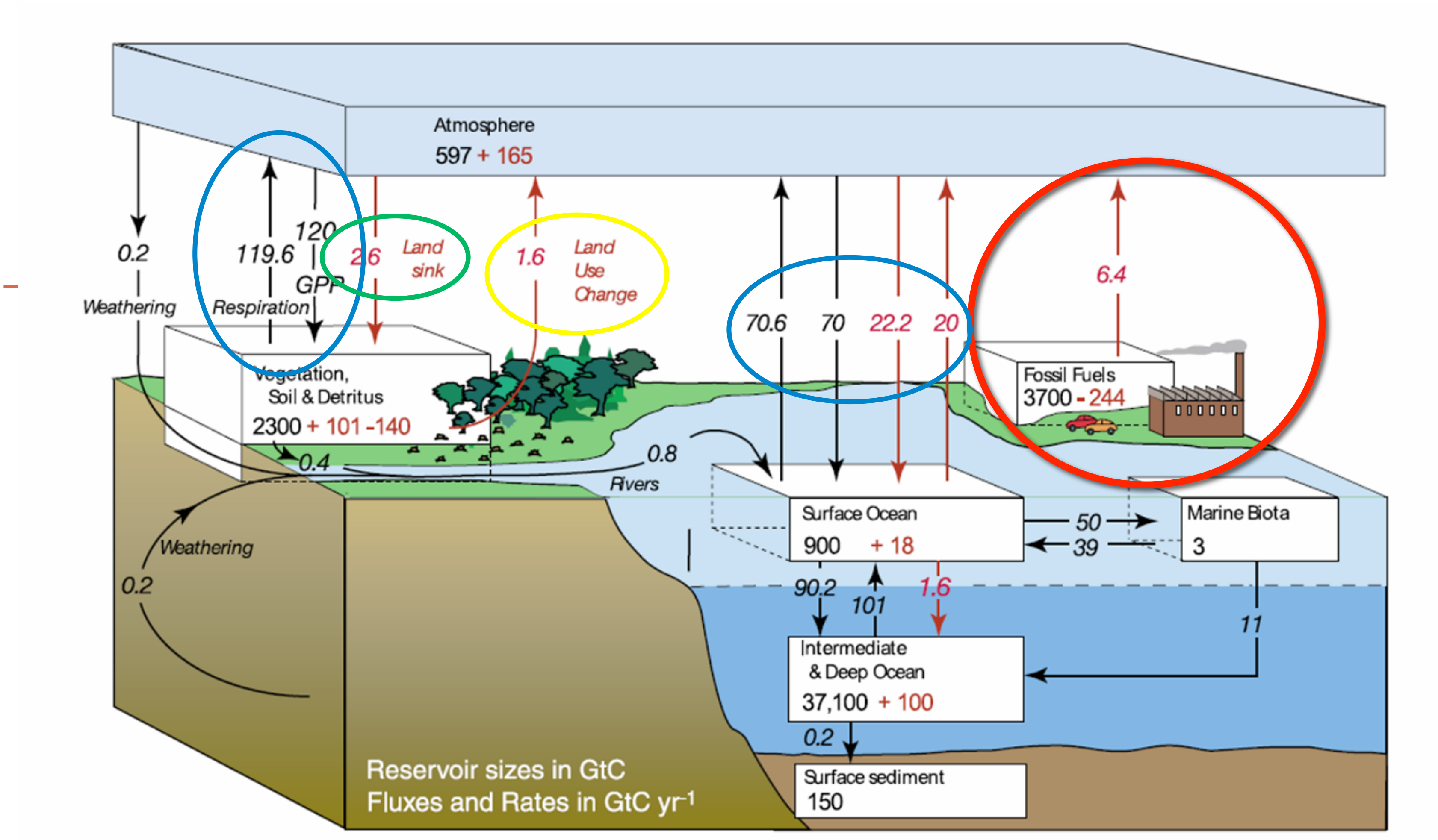
- Assembled, assessed, and summarized the more than 135 scientific peer-review articles.
- Revealed *four key insights* important to correctly understanding the impacts of using forest biomass for energy.
- Peer-reviewed article in the November issue of the *Journal of Forestry.*

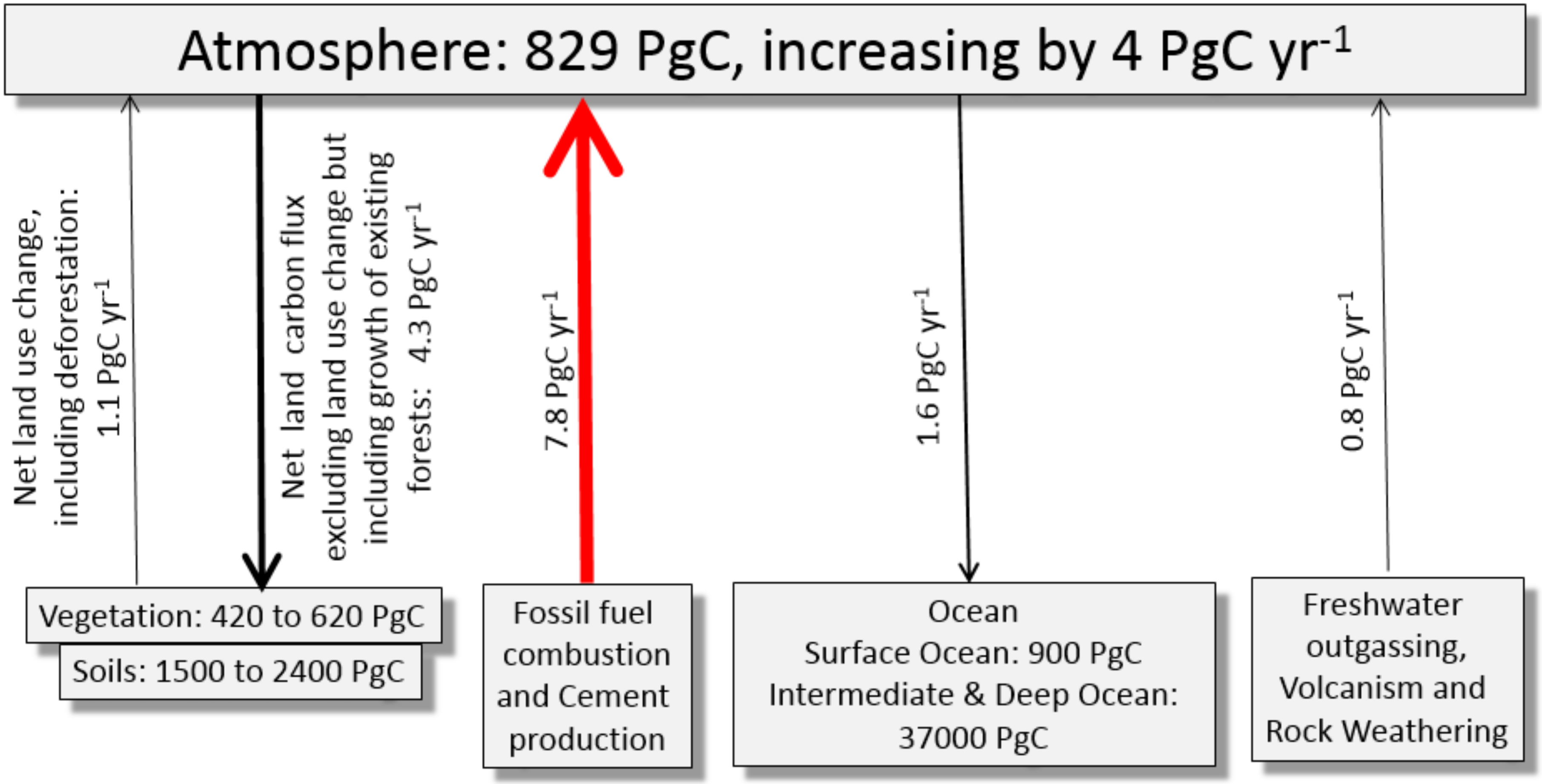
Atmospheric CO_2 Concentrations



The Basics: The Carbon Cycle



The Basics: The Carbon Cycle



Source: IPCC Fifth Assessment Report, WGI report – Figure 6.1.
Line widths proportional to amount of flow

The Basics: The Carbon Cycle

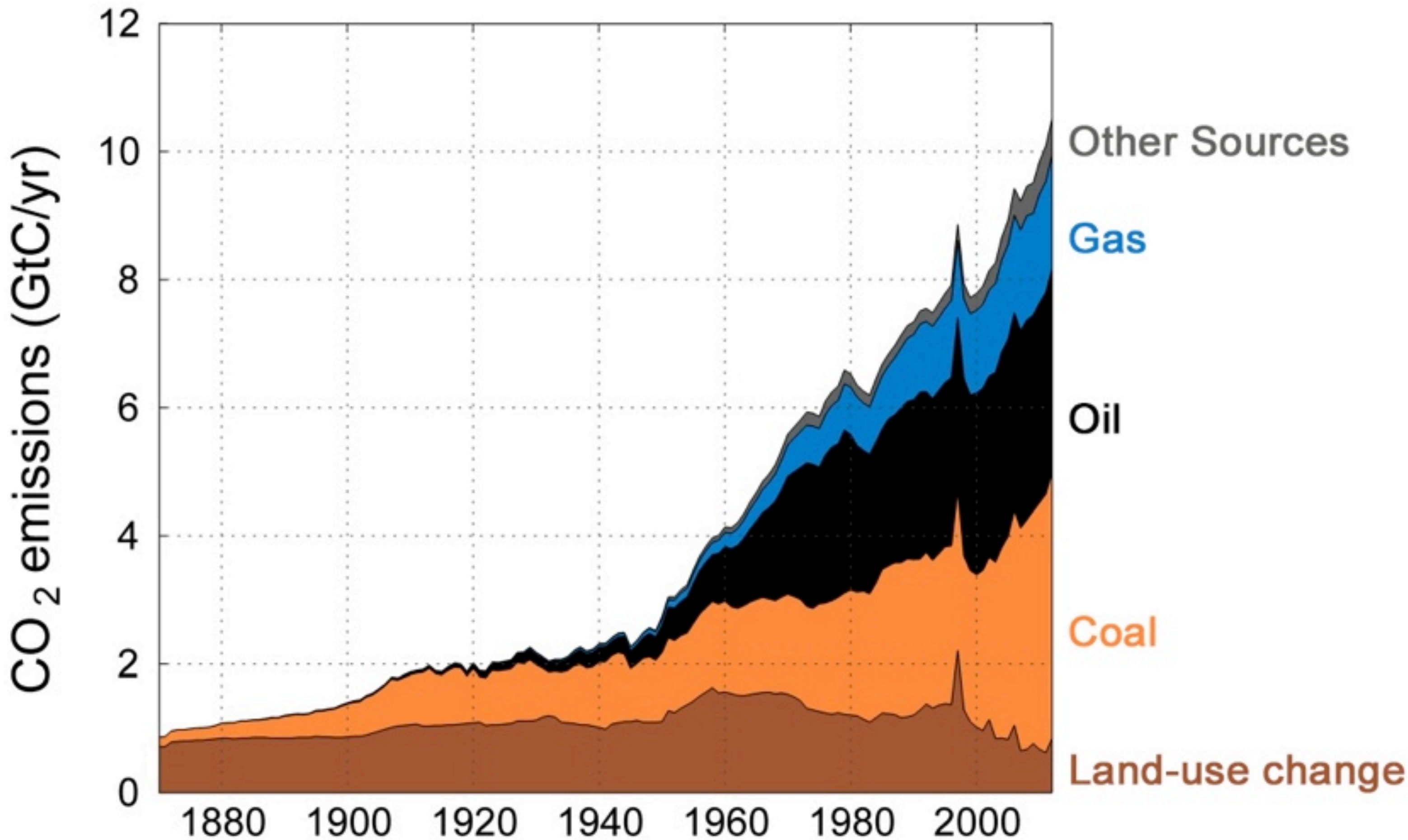


Figure adapted from Carbon budget and trends 2013.
[www.globalcarbonproject.org/carbonbudget] released on 19 November 2013

Insight 1: Substituting Forest Biomass for Fossil Fuels Provides Real, Permanent Benefits

- As long as wood-producing land remains in forest, forest-based bioenergy reduces: (1) fossil fuel use, and (2) long-term carbon emission impacts.

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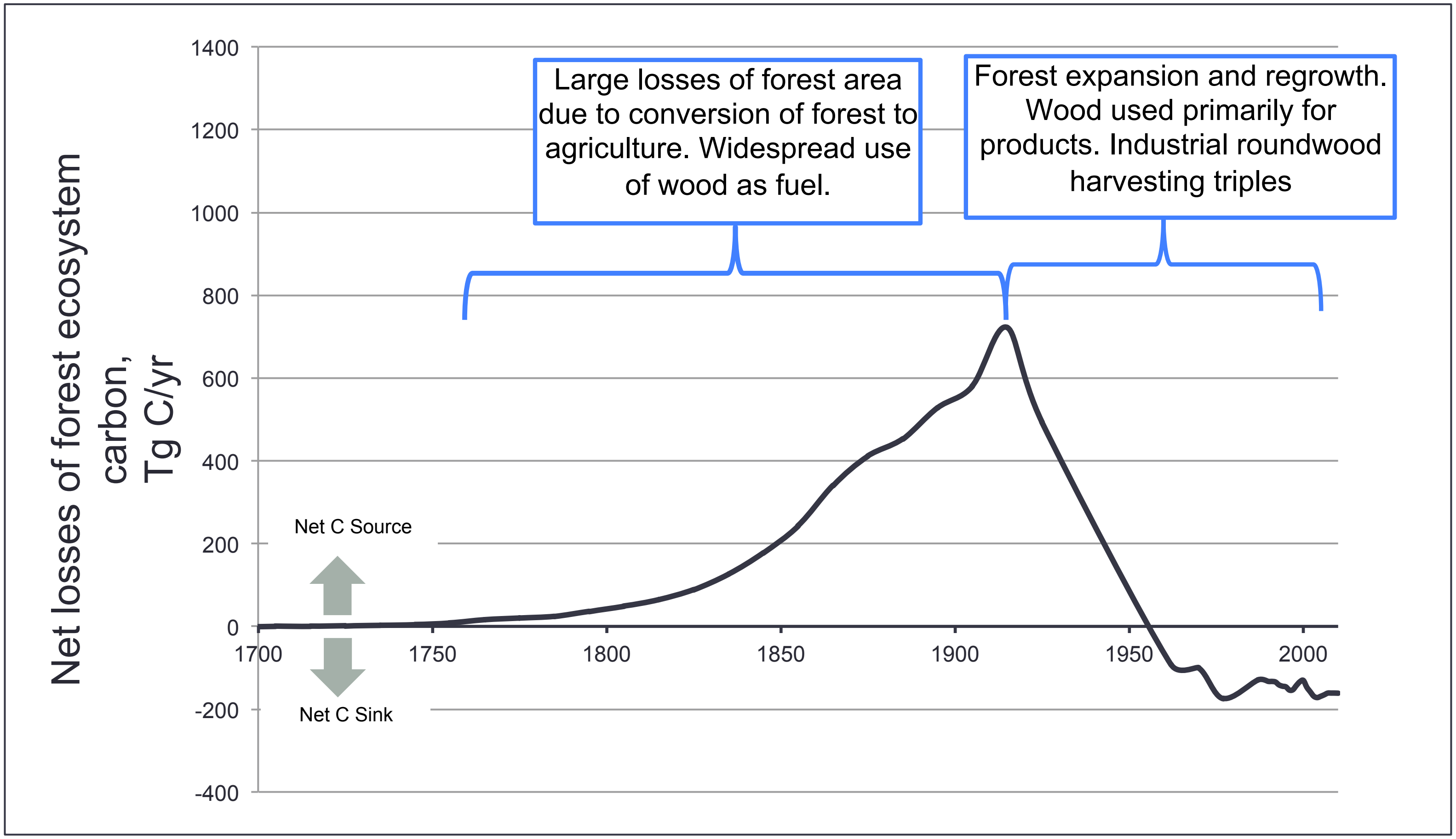
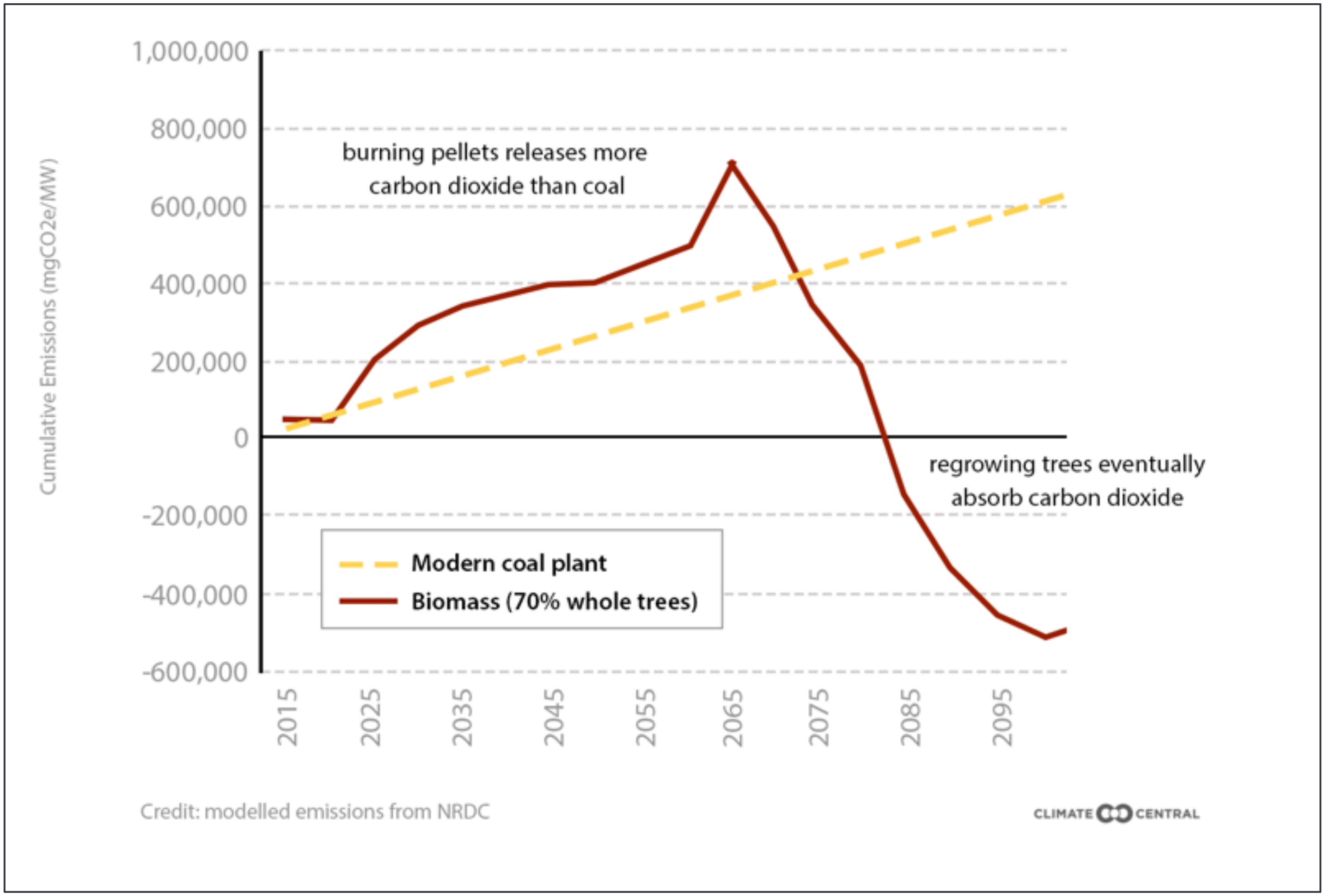


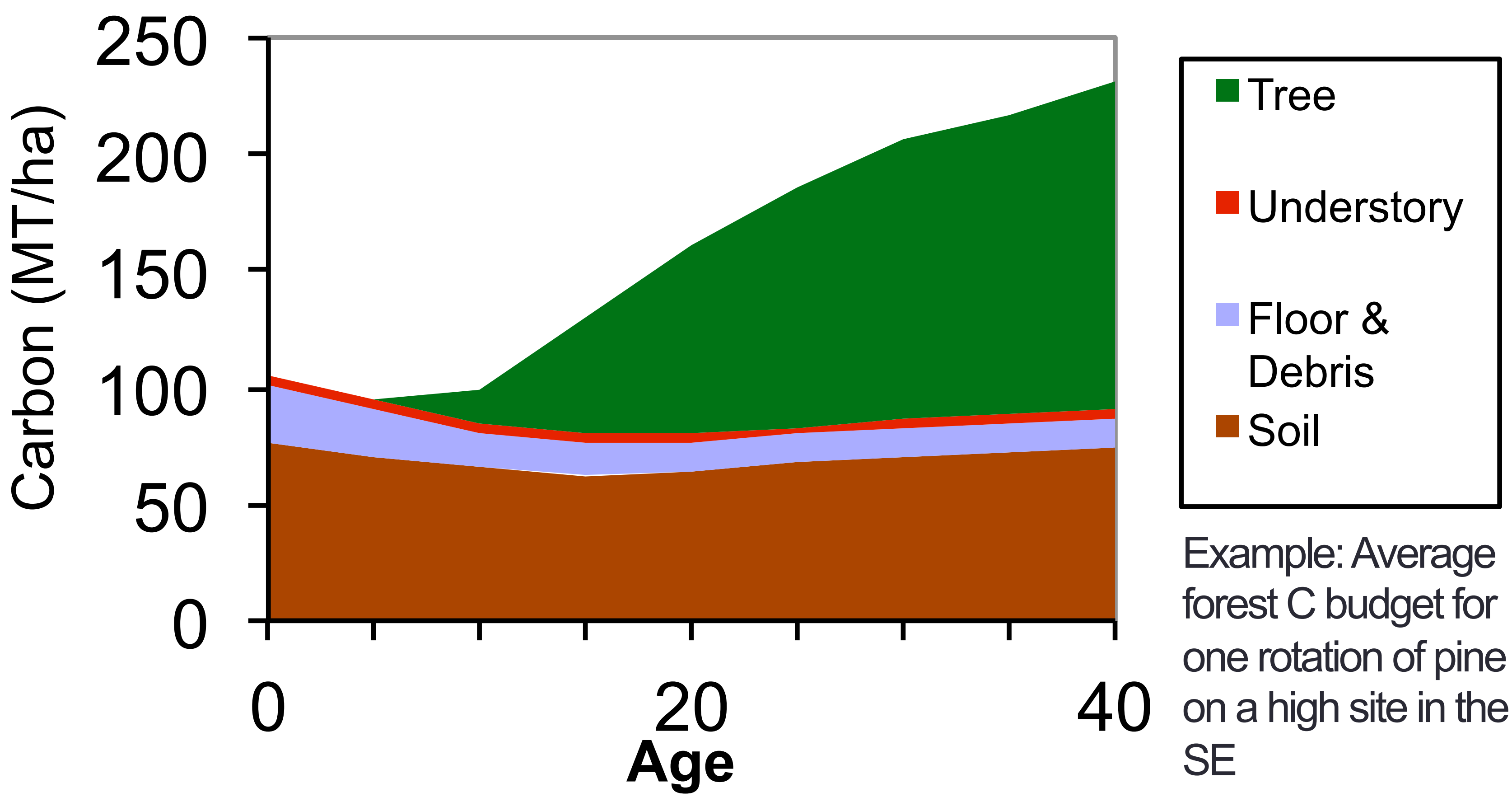
Insight 1: Substituting Forest Biomass for Fossil Fuels Provides Real, Permanent Benefits

- As long as wood-producing land remains in forest, forest-based bioenergy reduces: (1) fossil fuel use, and (2) long-term carbon emission impacts.
  - Near term emissions are sometimes higher (i.e., produce a carbon debt), but long-term cumulative emissions reduced.
  - The debate is about the timing of benefits, not whether these benefits exist.

Insight 1: Substituting Forest Biomass for Fossil Fuels Provides Real, Permanent Benefits

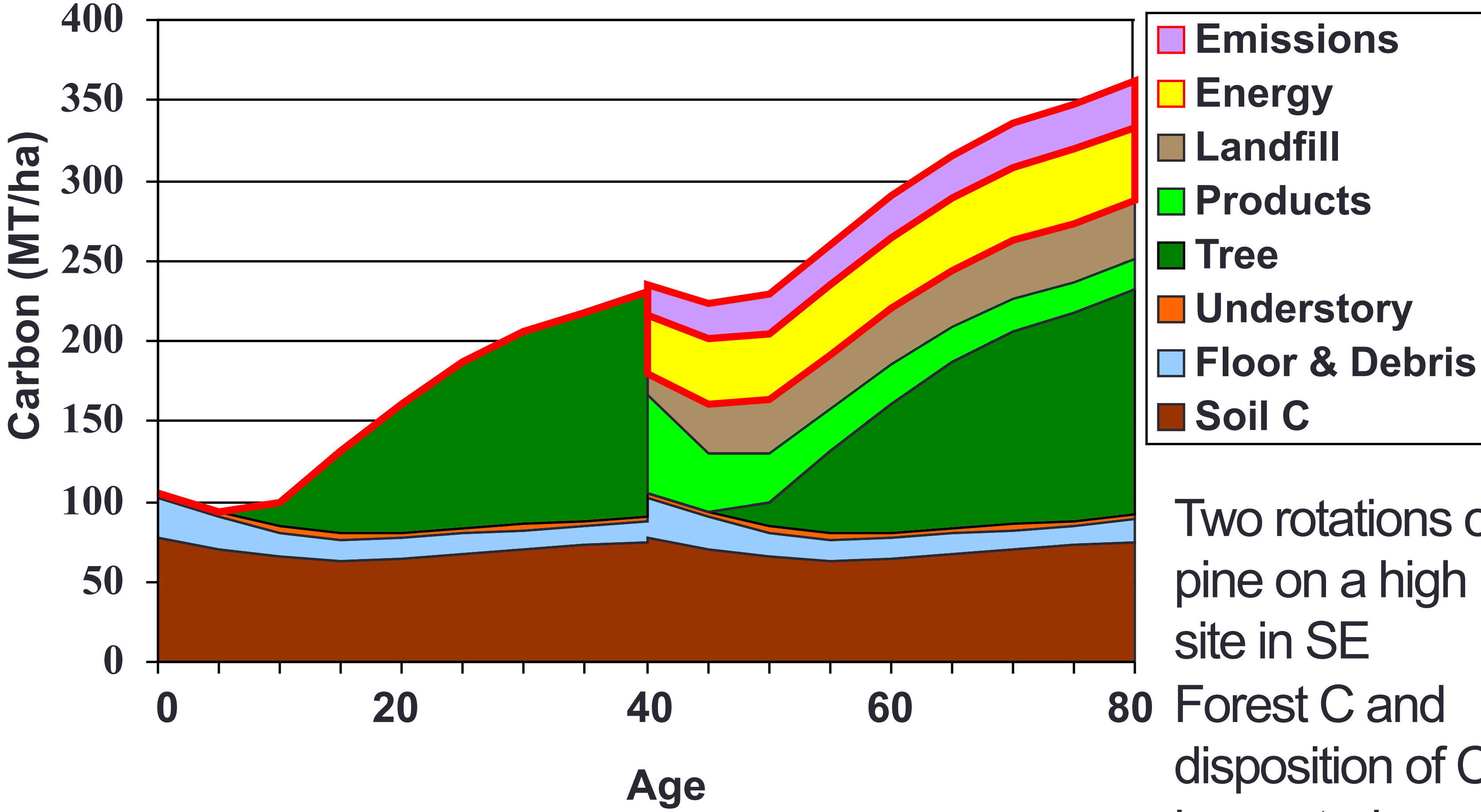


Insight 1: Substituting Forest Biomass for Fossil Fuels Provides Real, Permanent Benefits



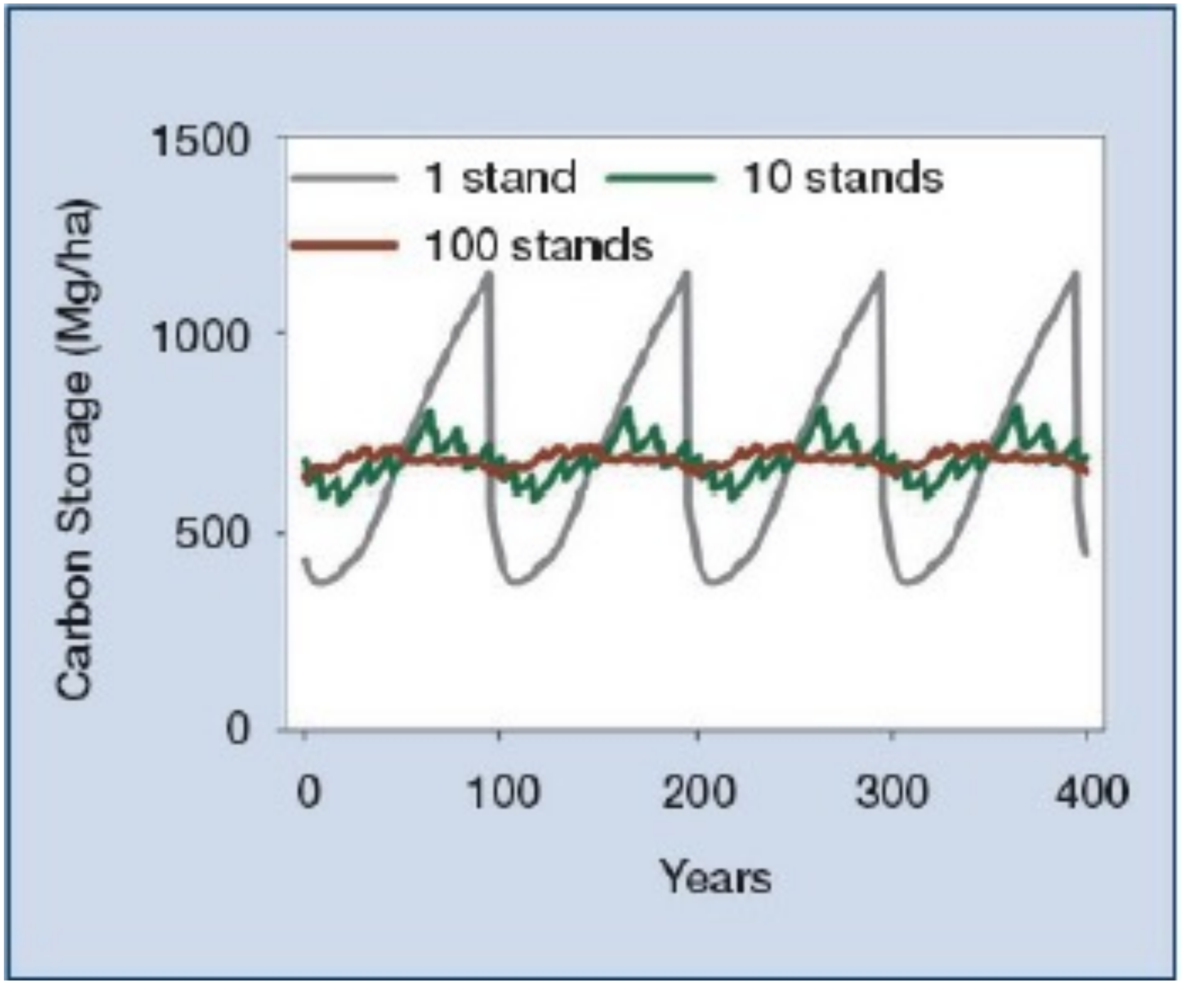
Example: Average forest C budget for one rotation of pine on a high site in the SE

Insight 1: Substituting Forest Biomass for Fossil Fuels Provides Real, Permanent Benefits



Two rotations of pine on a high site in SE Forest C and disposition of C in harvested wood

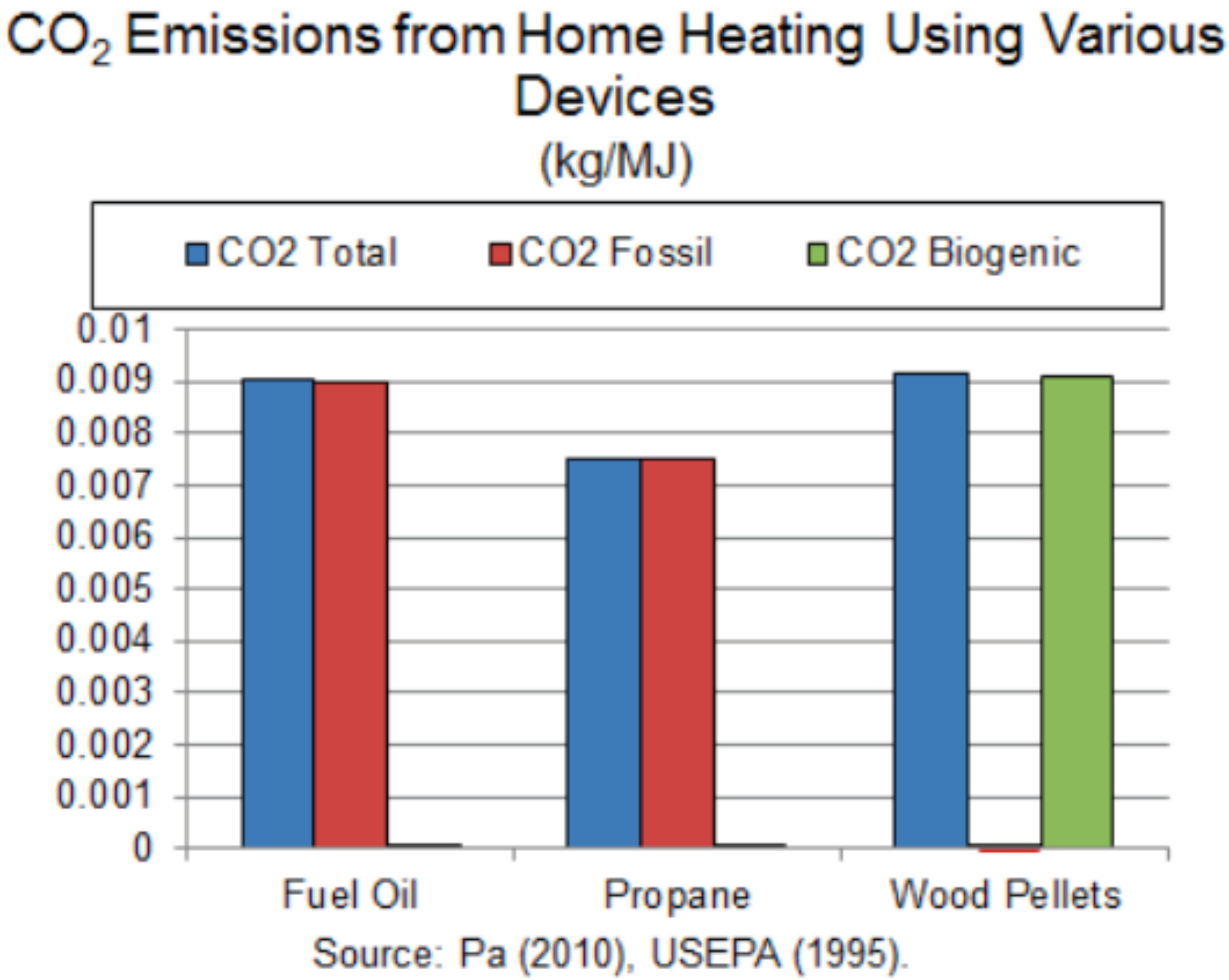
Insight 1: Substituting Forest Biomass for Fossil Fuels Provides Real, Permanent Benefits



Scale Matters: Site vs. Landscape Dynamics

Insight 1: Substituting Forest Biomass for Fossil Fuels Provides Real, Permanent Benefits

Wood Boiler Emissions

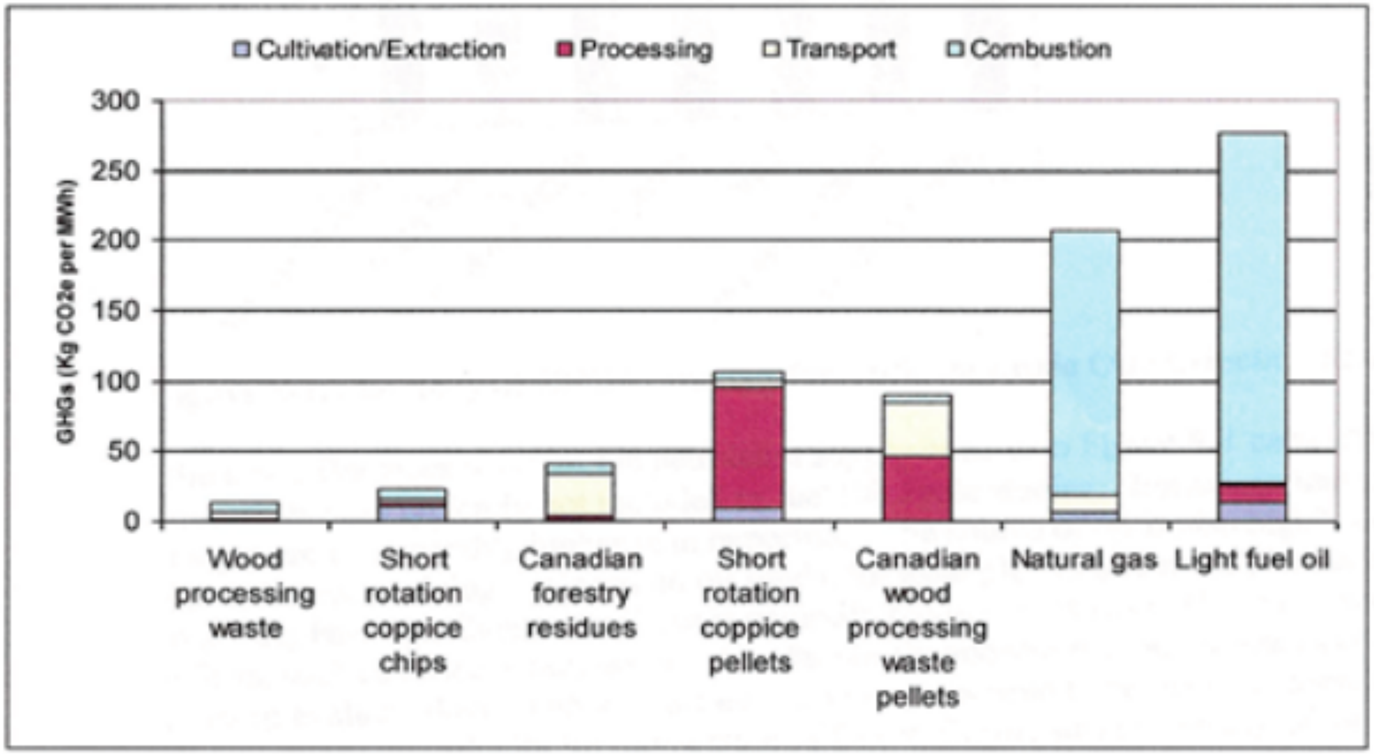


Source: Bowyer 2012. Life Cycle Impacts of Heating with Wood in Scenarios Ranging from Home and Institutional Heating to Community Scale District Heating Systems

Insight 1: Substituting Forest Biomass for Fossil Fuels Provides Real, Permanent Benefits

Wood Boiler Emissions

GHG Life Cycle Emissions from Production and Consumption of Various Fuels



Source: Bates and Henry (2009).

Source: Bowyer 2012. Life Cycle Impacts of Heating with Wood in Scenarios Ranging from Home and Institutional Heating to Community Scale District Heating Systems

Insight 2: Long-term Cumulative CO_2 Emissions Will Determine Peak Temperatures

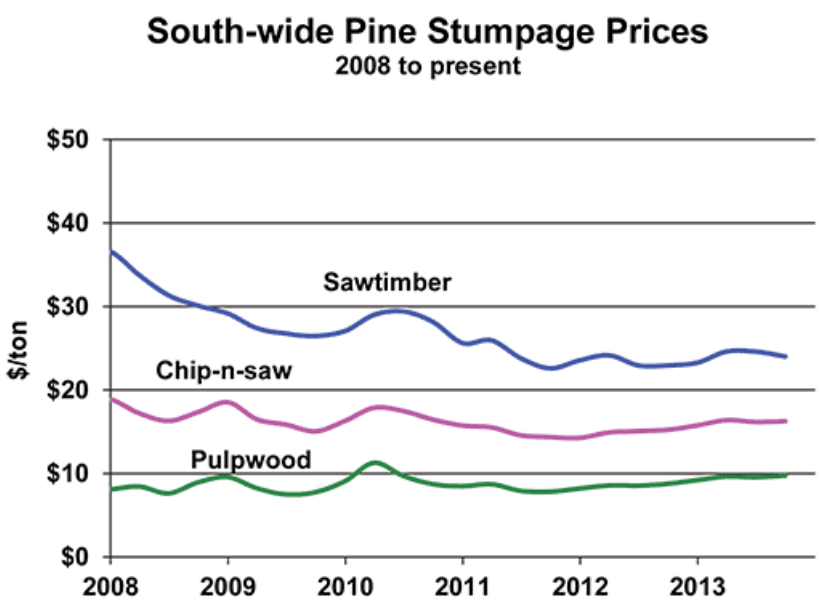
- The carbon debt concept emphasizes short-term concerns about biogenic CO_2 emissions.
- However, according to the most recent IPCC Assessment Report, long-term cumulative CO_2 emissions are correlated with projected peak global temperature.
- Forest bioenergy reduces long-term cumulative CO_2emissions.

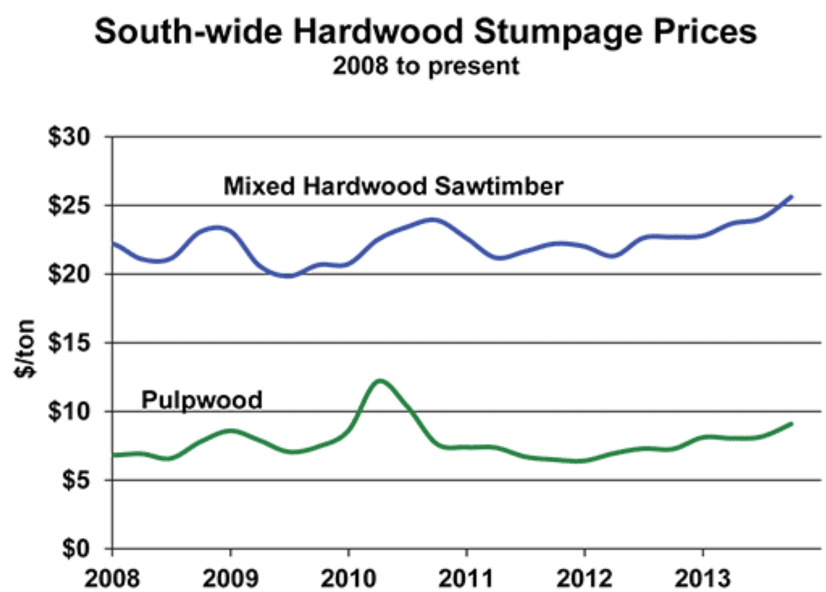
Insight 3: Correctly Characterizing Net GHG Emissions from Forest Biomass

- Considering forest growth, investment responses, and the radiative forcing of biogenic CO_2 over a 100-year time horizon (as used for other GHGs), the use of *forest biomass most likely to be used* for bioenergy *results in low net GHG emissions*, especially compared to fossil fuels.

Insight 3: The forest biomass most likely to be used for bioenergy results in low GHG emissions.

- The types of forest biomass likely to show the longest times to obtain net benefits (e.g. large trees) are unlikely to be used for energy where they can be sold into a higher value market (e.g. sawtimber).





(Figures from TimberMart-South)

Insight 3: 100-year GWPs for Biogenic CO_2 from Use of Forest Bioenergy

Using a time horizon of less than 100 years for judging impacts (net radiative forcing) from biogenic CO_2 is fundamentally inconsistent.

	20-year GWP	100-year GWP
CO_2	1	1
CH_4	72	25

Two Approaches for Calculating 100 Year GWPs for Biogenic CO_2 Emissions		
	Cherubini et al. (2011) approach	Helin et al. (2013) approach
Loblolly Pine on 20-year Rotation	0.12	0.26
Massachusetts Roundwood in Manomet Study	?	0.68

Insight 4: Increased Demand for Wood Reduces Carbon Impacts.

- Increased demand for wood triggers investments that increase forest area and forest productivity that reduce the conversion of forests to other land uses.

- Evidence:
  - Observations over time, empirical studies, and modeling.
- US Forest Service:
  - Strong markets reduce the *greatest threat to U.S. forests*: Conversion to other land uses.

Conclusion

"In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, *while producing an annual sustained yield of timber, fibre, or* ***energy*** *from the forest*, will generate the largest sustained mitigation benefit."

Source: Energy Policy and Climate Change
IPCC (4th Assessment Report)