The North American Terrestrial Carbon Sink
A Perspective on Managing Fossil Fuel CO_2 Emissions
Findings of the First U.S. Climate Change Science Program State of the Carbon Cycle Report (SOCCR)

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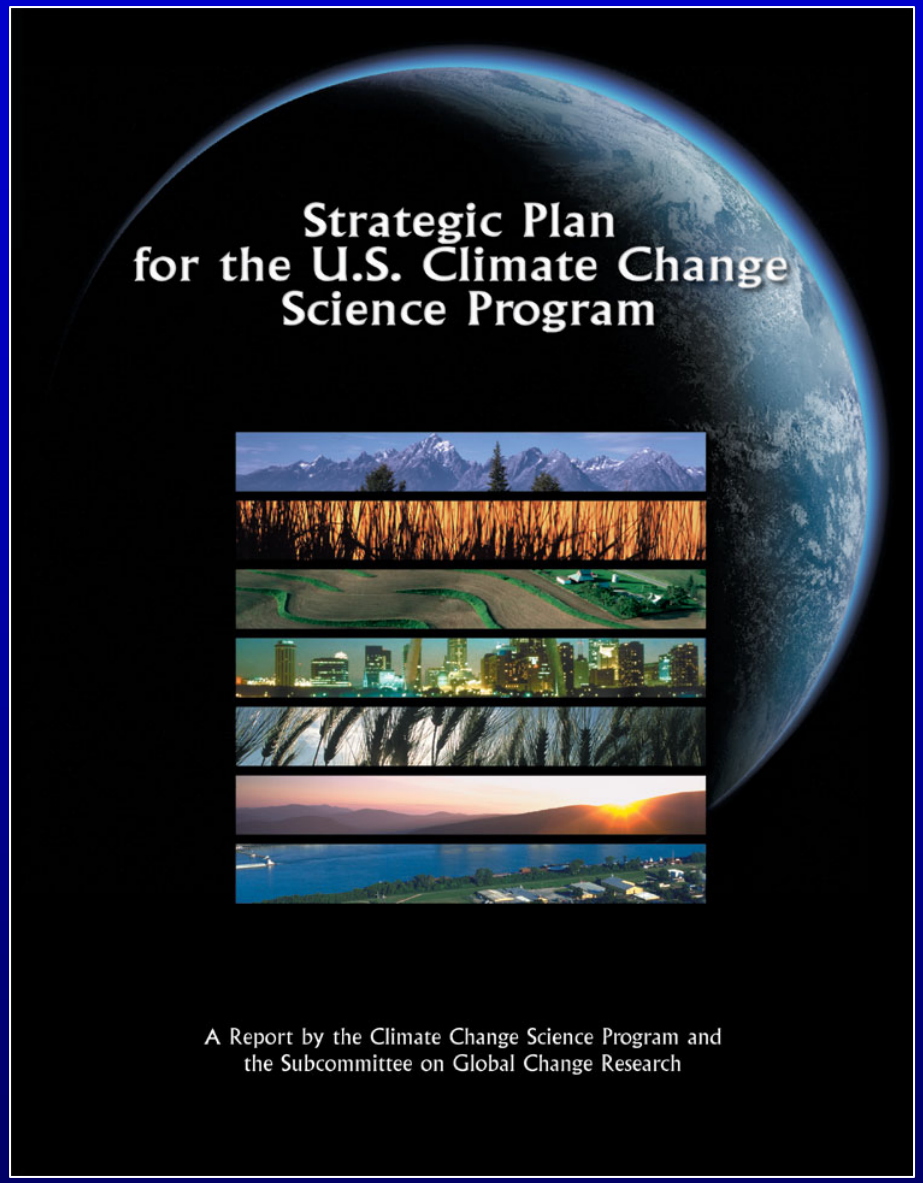


The *U.S. Climate Change Science Program (CCSP) Strategic Plan* of July 2003 calls for the creation of a series of more than 20 synthesis and assessment reports

"These products will support both policymaking and adaptive management."

Under CCSP Goal 2: Improve quantification of the forces bringing about changes in the Earth's climate and related systems.

Topics for Priority CCSP Synthesis Products include

--- North American carbon budget and implications for the global carbon cycle.

U.S. CCSP Synthesis and Assessment Product 2.2
The First State of the Carbon Cycle Report (SOCCR): North American Carbon Budget and Implications for the Global Carbon Cycle

CCSP Synthesis and Assessment Product 2.2, *The First State of the Carbon Cycle Report* --- SOCCR

- Is a community document, 15 chapters authored by more than 90 leading scientific experts
- Includes lead chapter authors from Canada, United States and Mexico
- Presents an integrated view of the carbon cycle
- Incorporated stakeholder interaction throughout the entire process
- Is intended for a diverse decision maker audience

`http://cdiac.ornl.gov/SOCCR/`

Currently revising Draft 3 in response to government review
Final Report posting is scheduled for late May 2007

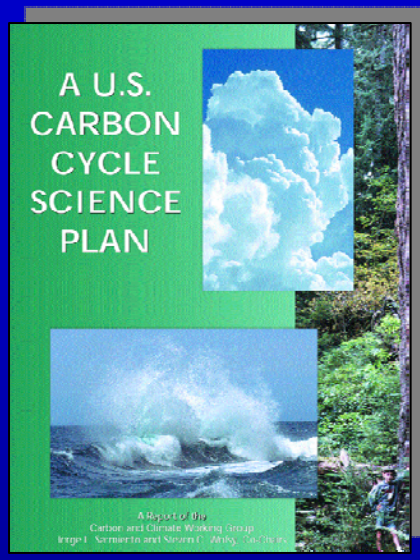
Acknowledgements

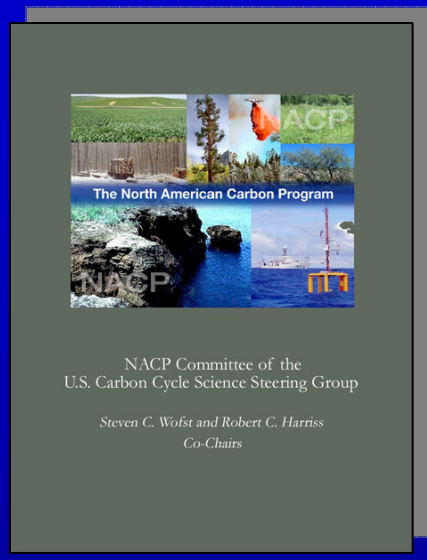
- Authors
- Stakeholders
- SOCCR Scientific Coordination Team
- SOCCR Agency Executive Committee
- Climate Change Science Program
- Our Agency Sponsors

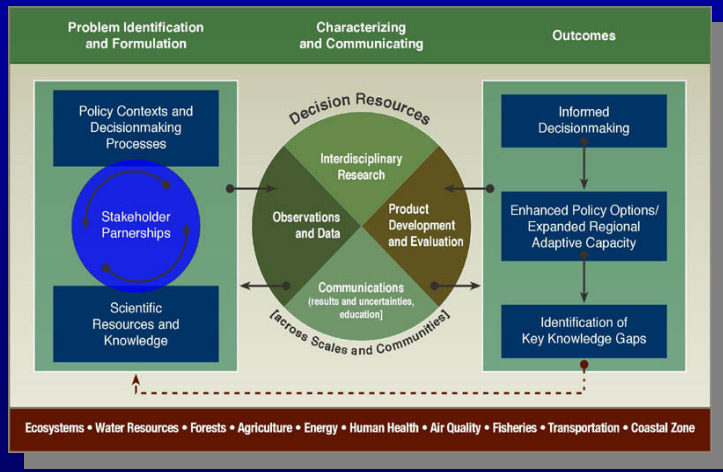
The purpose of SAP 2.2 is twofold:

1. To summarize scientific knowledge about carbon cycle properties and changes for North America.

2. To provide scientific information for decision support and policy formulation concerning carbon.





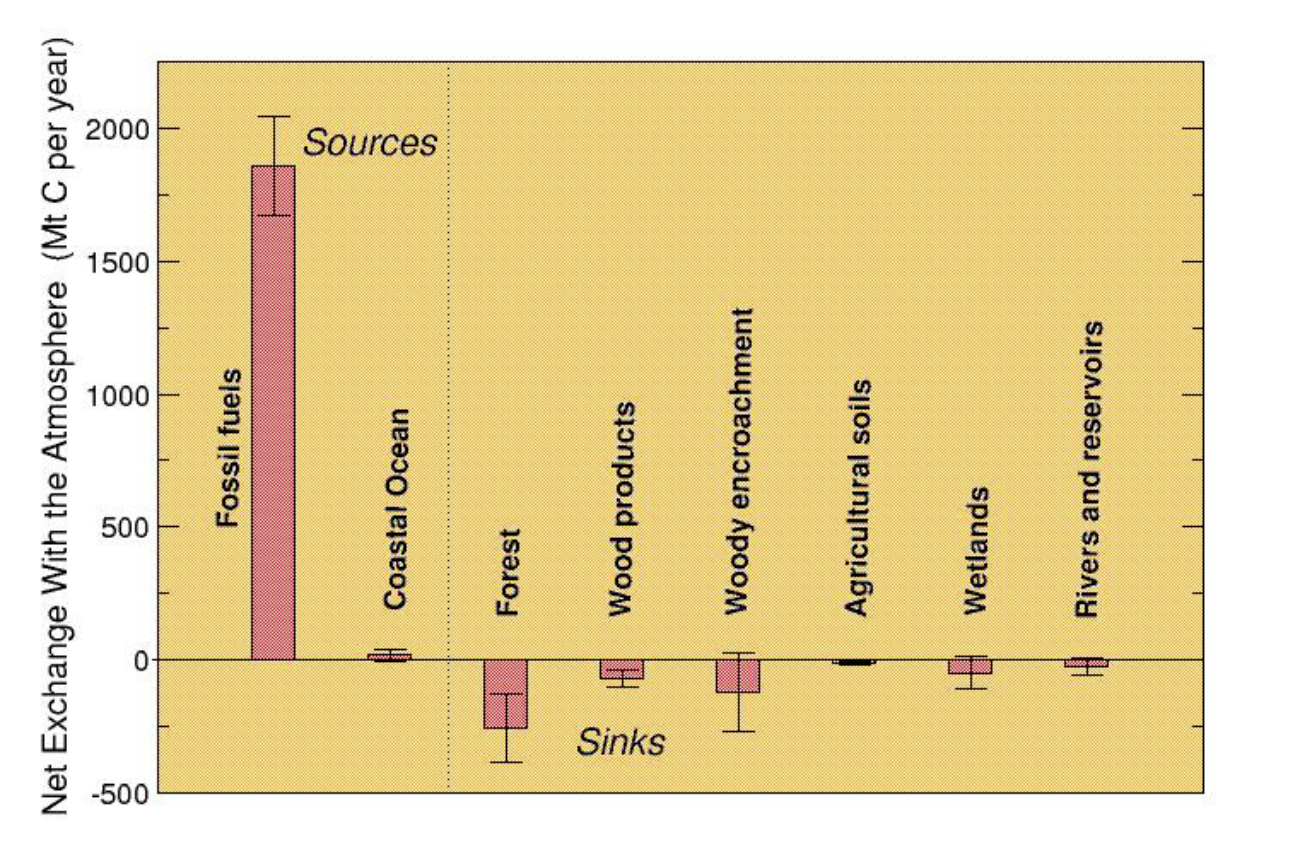


US CCSP Decision Support Strategy

Questions covered in the report

1. What is the carbon cycle, and why care?
2. How do North American carbon sources and sinks relate to the global carbon cycle?
3. What are the primary carbon sources and sinks in North America, and how and why are they changing?
4. What are the direct, non-climatic effects of increasing atmospheric CO_2 or other changes in the carbon cycle on the land and oceans of North America?
5. What options can be implemented in North America that could significantly affect the North American and global carbon cycles?
6. How can we improve the usefulness of carbon science for decision-making?
7. What additional knowledge is needed for effective carbon management?

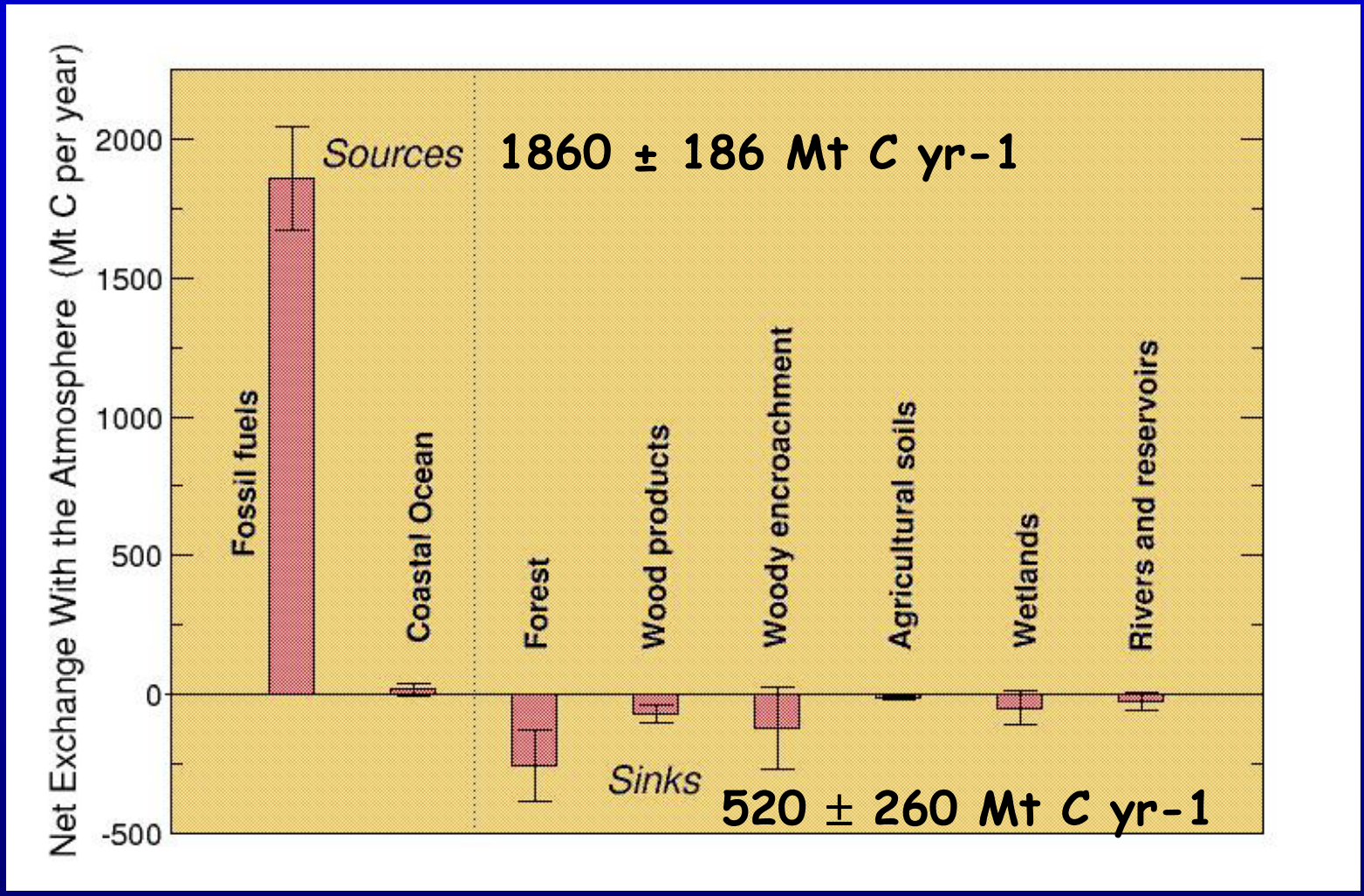
3. What are the primary carbon sources and sinks in North America; how and why are they changing?



North America is currently a net carbon source of 1336 ± 334 Mt C yr^{-1}. A net terrestrial sink of 520 ± 260 Mt C yr^{-1} is equivalent to about 30% of fossil fuel emissions in 2003.

Treatment of uncertainty in SAP 2.2

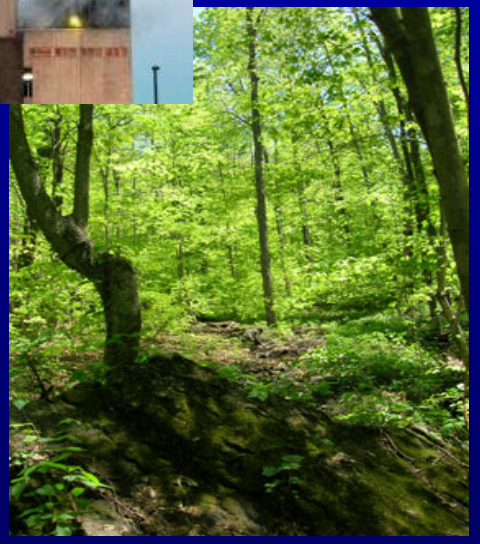
- Sources of uncertainty vary across sectors
  - Variation in time and space, measurement and sampling error, uncertainty in “expansion factors” and analytical models
  - Uncertainty about future socio-economics and the environment, in response to perturbation, in forecasting models
- To synthesize across this uncertainty and provide comparability we employed a characterization expressing relative confidence in a quantity
  - 95% certain that the actual value is within 10% of the estimate reported
  - 95% certain that the estimate is within 25%
  - within 50%
  - within 100%
  - uncertainty > 100%



The balance: a net N. American carbon source of 1340 Mt C yr^{-1} (±25%). A source:sink ratio of greater than 3:1

3. cont. What are the primary carbon sources and sinks in North America; how and why are they changing?

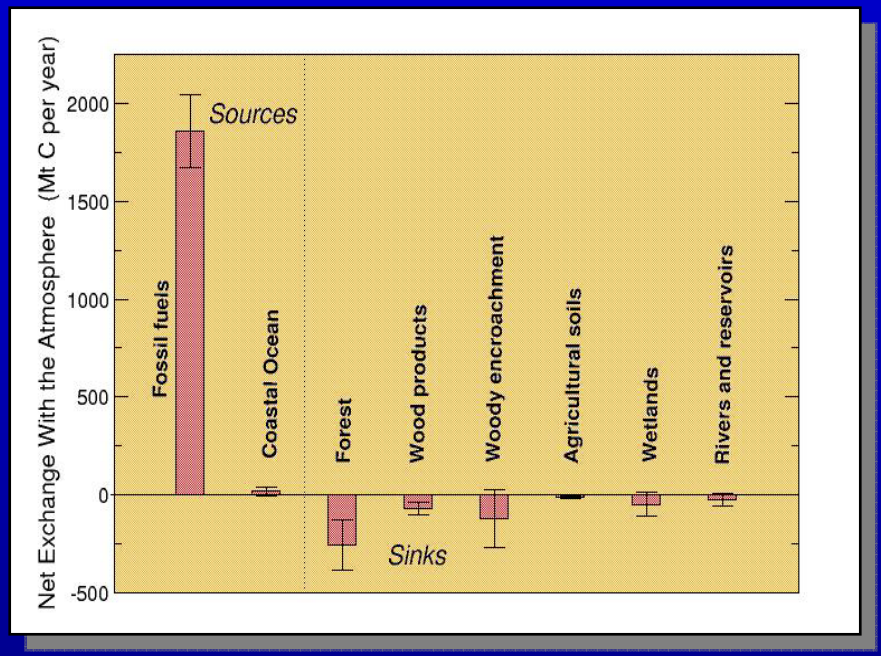
- Fossil-fuel emissions are dominated by emissions from the United States (85% in 2003; Canada 9% and Mexico 6%).
- Electricity generation is the largest contributor, transportation the second.
- The terrestrial sink is primarily associated with regrowing forests in the United States (≈ 50% of the sink).
- The future of the North American terrestrial sink is highly uncertain, with the expectation that the forest regrowth contribution will decline as forests mature clouded by uncertainty in ecosystem response to CO_2 and climate.



A Perspective on Managing Fossil Fuel CO_2 Emissions

From SAP 2.2's new synthesis of the North American carbon budget.

- Terrestrial sinks (ca. 2003) are collectively only 30% of fossil fuel emissions.
- Forest regrowth is currently the dominant sink.
- The future trajectory of sinks is highly uncertain.



- Effective management of North America's contribution to global increases in atmospheric CO_2 would likely need to focus on fossil fuel emissions.
- Options focused on enhancing sinks can contribute but are likely insufficient to deal with magnitude of current imbalance

Backup Slides

Goals for Stakeholder Involvement in the SOCCR SAP 2.2

- Make the SOCCR as relevant as possible to policy/management concerns, without being policy prescriptive
- Engage a diverse and representative group of carbon cycle management stakeholders
  - government, business, public interest groups and academia
- Ensure that the authorship and process of developing the SOCCR are transparent and credible

SOCCR SAP 2.2
Stakeholder Involvement Process

- Identification of key stakeholder constituencies
- Initial Stakeholder Rapid Assessment
- 3 stakeholder workshops (one joint with authors)
- Public comment periods (from outline stage onward), technical review
- Public web site for information and comment
  http://cdiac.ornl.gov/SOCCR/
- Electronic newsletter (listserv)
- Briefings at relevant meetings (AGU, CCSP, NACP)

The Structure of SAP 2.2

There are three parts to SAP 2.2, prefaced by an Executive Summary:

Part I:
The Carbon Cycle in North America
- five chapters

Part II:
Energy, Industry and Waste Management Activities
- four chapters

Part III:
Land and Water Systems
- six chapters

Part I: The Carbon Cycle in North America

- **Chapter 1. What is the Carbon Cycle and Why Do We Care?**
  - **SOCCR Coordinating Team**
- **Chapter 2. The Carbon Cycle of North America in a Global Context**
  - **Chris Field (Coordinating Lead), Burke Hales, Jorge Sarmiento**
- **Chapter 3. The North American carbon Budget Past and Present?**
  - **Steve Pacala (Coordinating Lead), Rich Birdsey, Scott Bridgham, Rich Conant, Ken Davis, Burke Hales, Richard Houghton, Jen Jenkins, Mark Johnston, Gregg Marland, and Keith Paustian**
- **Chapter 4. What are the Options and Measures That Could Significantly Affect the Carbon Cycle?**
  - **Erik Haites (Coordinating Lead), Ken Caldeira, Patricia Romero Lankao, Adam Rose, Tom Wilbanks**
- **Chapter 5. How Can We Improve the Usefulness of Carbon Science for Decision-Making?**
  - **Lisa Dilling and Ron Mitchell (Coordinating Leads), David Fairman**

Lead authors for Part II and III were asked to cover:

- Inventories
  - Emissions
  - Stocks and fluxes
- Trends and drivers
  - Historical
  - Future
- Options for management
  - Near term (2015-2025)
  - Far term (2050 and beyond)
- Research and development needs
  - Which questions, if answered, or options, if developed, would significantly change the discussion about options for carbon management

Part II: Energy, Industry and Waste Management Activities

Overview of Part II: Energy, Industry, and Waste Management Activities: An Introduction to CO_2 Emissions from Fossil Fuels
-- Gregg Marland

- Chapter 6: Energy Extraction and Conversion
  -- Thomas Wilbanks

- Chapter 7: Transportation
  -- David Greene

- Chapter 8: Industry and Waste Management
  -- John Nyboer

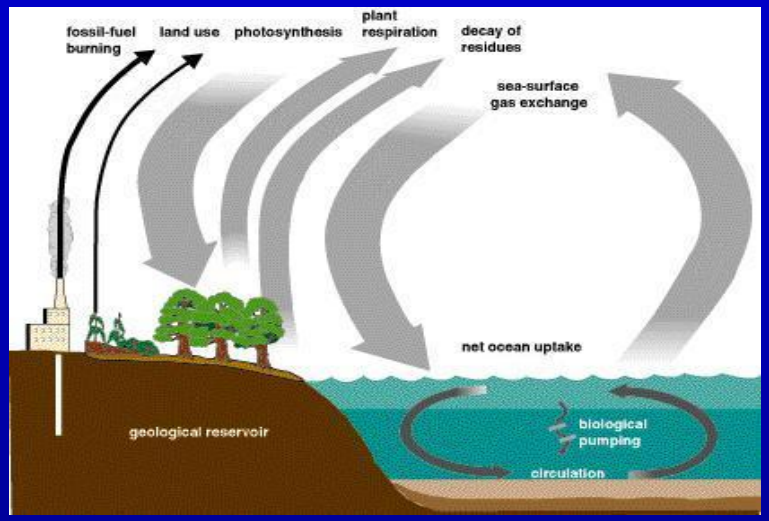
- Chapter 9: Buildings
  -- James McMahon

Part III: Land and Water Systems

- Overview of Part III: The Carbon Cycle in Land and Water Systems
  - Richard (Skee) Houghton
- Chapter 10. Agriculture and Grazing Lands
  - Rich Conant and Keith Paustian
- Chapter 11. North American Forests
  - Richard Birdsey, Jennifer Jenkins, Mark Johnston and Elisabeth Huber-Sannwald
- Chapter 12. Carbon Cycle in the Permafrost Region of North America
  - Charles Tarnocai
- Chapter 13. Wetlands
  - Scott Bridgham
- Chapter 14. Human Settlements and the North American Carbon Cycle
  - Diane Pataki
- Chapter 15. Coastal Oceans
  - Francisco Chavez and Taro Takahashi

1. What is the carbon cycle, and why care?

- The carbon cycle is the many processes that transfer carbon between land, ocean and atmosphere, that influence concentration of carbon dioxide (CO_2), an important greenhouse gas, in the atmosphere.



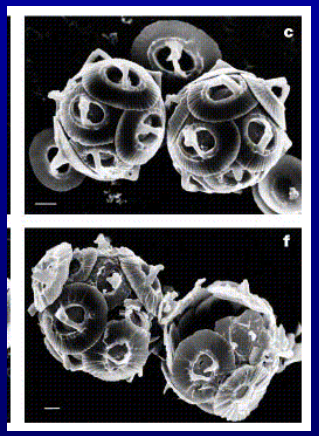
- Human activities have significantly altered the balance of *sources* that add CO_2 to the atmosphere and *sinks* that remove it. The result is a buildup of CO_2 in the atmosphere.

- Understanding the carbon cycle and human influence on sources and sinks is crucial to any effort to mitigate potential climate change by stabilizing atmosphere CO_2 concentrations.

2. How do North American carbon sources and sinks relate to the global carbon cycle?

- In 2004 North America was responsible for approximately 25% of CO_2 emissions produced globally by fossil fuel combustion.
- North America also contributed approximately 30% of cumulative CO_2 emissions from fossil-fuel combustion since 1750.
- Previous analyses suggest land sinks in North America may account for perhaps 25% of the global terrestrial carbon sink.
- But that estimate is very uncertain and this report is in part an effort to better quantify the North American sink.

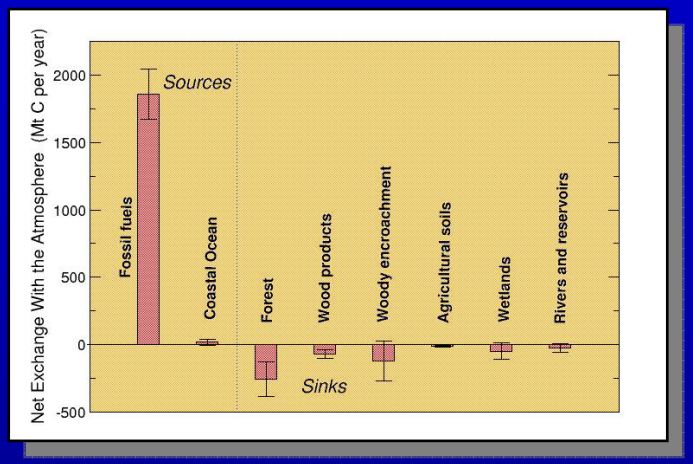
4. What are the direct, non-climatic effects of increasing atmospheric carbon dioxide or other changes in the carbon cycle on the land and oceans of North America?

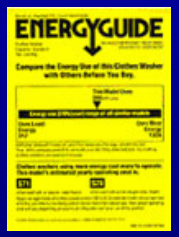


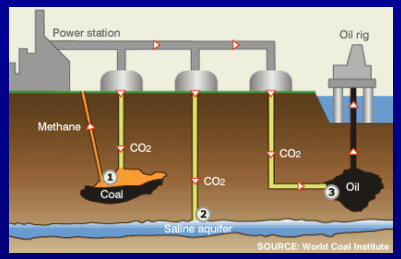
U Riebesell et al. 2000
Nature, **407,364-7**

- Experimental studies suggest that elevated CO_2 will enhance plant growth.
- But field studies are still not definitive and the future response of ecosystems is uncertain.
- Elevated atmospheric CO_2 is increasing the acidity of the ocean, with potentially serious consequences for marine organisms.

5. What options can be implemented in North America that could significantly affect the North American and global carbon cycles ?



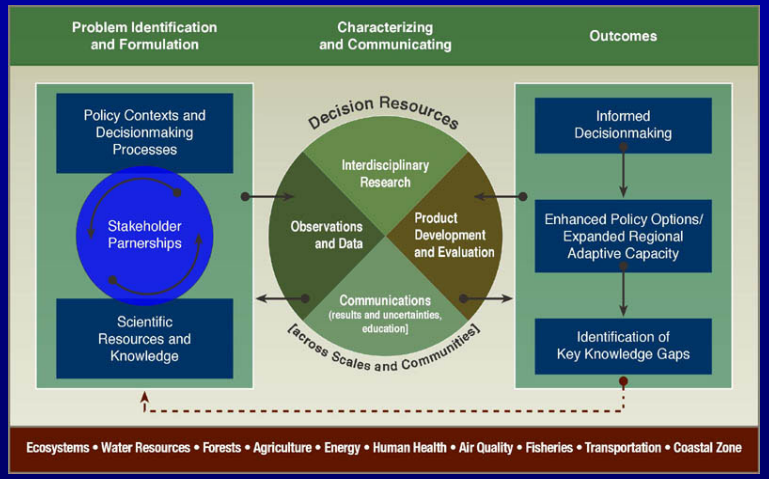




- Addressing imbalances in North American carbon budget requires options focused on reducing fossil fuel emissions.
- Emission-related options include efficiency improvement, fuel switching, alternative energy sources, and technologies such as capture and storage.
- Options focused on enhancing sinks can contribute but are likely insufficient to deal with magnitude of current imbalance.
- Policy and economic analyses suggest effective mechanisms will likely be a mix of voluntary and policy-driven options, locally, regionally, nationally, and internationally.

6. How can we improve the usefulness of carbon science for decision-making?

- Demand for information by decision makers will require new thinking and mechanisms in carbon cycle research.
  - Identify categories of decision makers (DMs) for whom carbon information is a relevant issue (problem orientation)
  - Work directly with DMs to understand context of their decisions and evaluate carbon impacts of actions in these contexts (two way, ongoing)



US CCSP Decision Support Strategy

7. What additional information is needed for effective carbon management?

- Determination of future research priorities should be done in collaboration with carbon managers and other stakeholders
- This applies to technology and policy options for reducing emissions and for carbon capture and storage
- It also applies to reducing scientific uncertainties most relevant to carbon management, including issues of verification for carbon sequestration.