

**Toward CO<sub>2</sub> Stabilization:  
Issues, Strategies, and Consequences**  
A SCOPE/GCP Rapid Assessment Project

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Human activities leading to increases in atmospheric CO<sub>2</sub> and consequent forcing of climate have helped focus broad interest on the carbon cycle, stimulating research on fundamental biogeochemical controls, human impacts, and options for future management. Effective action to minimize future climate changes will involve many aspects of the carbon cycle, from the efficiency of power generation, through the persistence of natural sinks, and options for engineering new sinks. The challenges in carbon cycle research include both disciplinary and interdisciplinary components. The SCOPE/GCP Rapid Assessment Project on the Carbon Cycle (RAPCC) is a synthesis of interdisciplinary understanding and a platform for enabling the next generation of interdisciplinary advances.

The goal of the RAPCC is a synthesis that places all aspects of the carbon cycle in a common framework. As the world moves toward a serious discussion of stabilizing atmospheric CO<sub>2</sub>, we will need a thorough understanding of each of the processes releasing or storing carbon dioxide. Key issues include the trajectories and capacities of unmanaged fluxes, as well as the implications of these fluxes for other ecosystem processes. For managed fluxes, key issues include technical feasibility, safety, and cost. Social factors will be important regulators of both economic cost and cultural acceptance.

Integrating biogeochemical, economic, engineering, and economic aspects of the carbon cycle is an ambitious, multi-year agenda. Much of that agenda will be coordinated by the new Global Carbon Project (a joint activity of the IGBP, IHDP, and WCRP). To launch that agenda, the RAPCC will provide a state-of-the-science assessment, consisting of approximately 20 brief background papers and 4 major synthesis papers, published as a fast-track book. The project will operate on the model of the Dahlem conferences, with background papers written before a 6-day meeting and an intensive effort at the meeting leading to nearly final versions of the synthesis papers. The meeting is planned for February 2-7, 2003, in Ubatuba, Brazil.

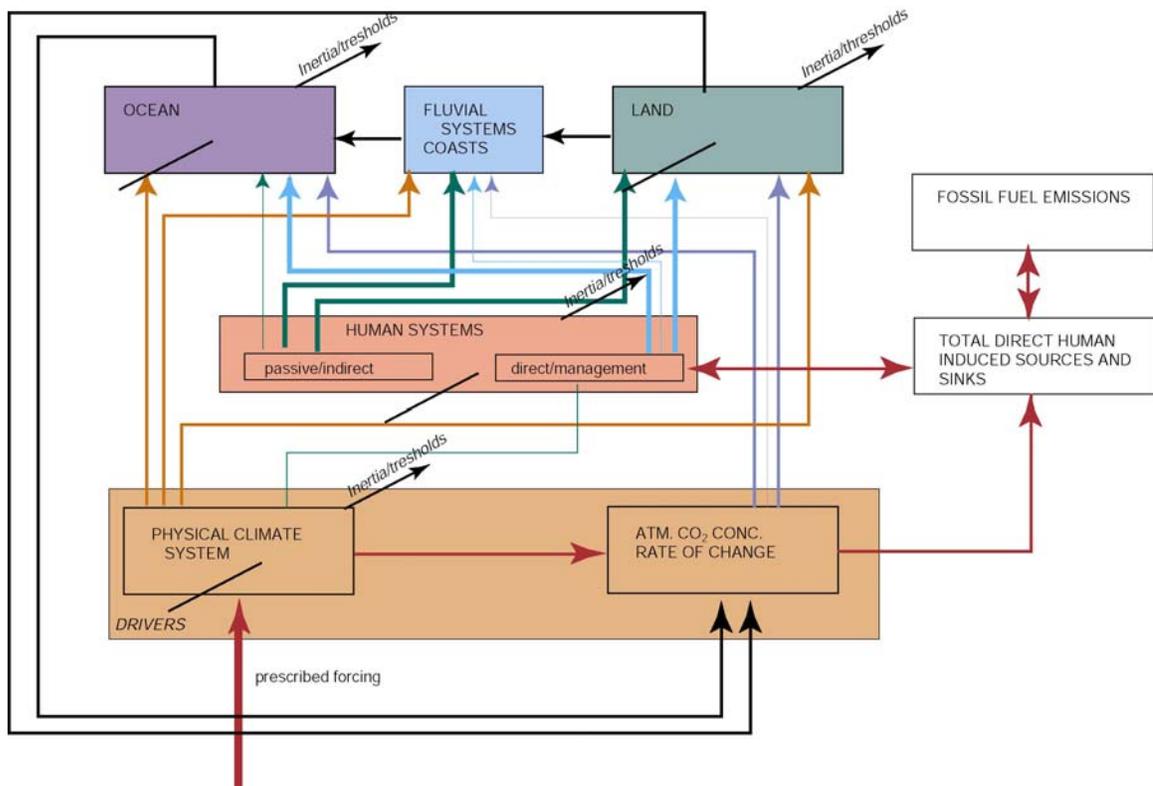


Figure 1: A carbon cycle wiring diagram, emphasizing how processes in all domains and at all time scales interact to modulate the prospects for effective management.

A common framework for all aspects of carbon cycle science is a key prerequisite for tackling the technical and social issues of moving toward the eventual stabilization of atmospheric CO<sub>2</sub>. To provide a solid foundation for science, policy, and social discussions, this common framework must address two kinds of fundamental challenges. First, aspects of the carbon cycle are highly interactive, both with each other and with the broader earth system. Until we have the sophistication to analyze all components of the carbon cycle in the context of a comprehensive “wiring diagram” (Fig. 1), we will lack the tools to address the full range of implications of particular management options. Second, the costs and benefits of various management options are very diverse. They span not only a long time period and many aspects of the economy but also processes that are outside the realm of traditional economic analysis.

The RAPCC synthesis will address a wide range of topics necessary to establish a common foundation for all aspects of carbon cycle science. The background papers for the synthesis will focus on individual aspects of the carbon cycle, including biogeochemical, technological, and social components. The synthesis chapters will outline a strategy for integrating these components, highlighting needs for observations, experiments, and models. The final product should be useful both as a state-of-the-science summary, and as a compass for next steps.

To provide this summary and guide to next steps, all of the papers, including the background papers, should be written with a view toward synthesis. Collectively, the background papers should address the following questions:

- What are the current contributions of each of the processes influencing atmospheric CO<sub>2</sub>?
- What are the time constants for each of these processes?
- How much of the current flux is inertial, reflecting continuing responses to past forcing?
- How do the processes interact, both with each other and with other aspects of the earth system?
- What are the vulnerabilities of the current stocks and fluxes to future forcing?
- What are the options for managing each component flux?
- How much will it cost to make meaning changes?
- What kinds of social structures could support these changes?
- What are the options for verification and attribution?

The four synthesis topics, addressing (1) Current status of the carbon cycle, (2) Future trends in the carbon cycle, (3) Potential for deliberate management of the carbon cycle, and (4) Carbon, climate, human interactions, will be the focus of discussions at the workshop. Each subgroup charged with considering one of these topics will, under the leadership of a chair and a rapporteur, draft a manuscript based on their discussions. The meeting will provide extensive administrative and logistic support, and the schedule will allow discussion participants to contribute to several synthesis chapters. Participants in the meeting will include synthesis chairs and rapporteurs, lead authors of the background papers, and a few additional carbon cycle scientists.

The background papers will be brief (2500-3000 word) summaries organized into six clusters on (1) social and economic drivers, (2) engineered sinks, (3) the carbon cycle on land, (4) the carbon cycle in the open ocean, (5) the carbon cycle in coasts and fluvial systems, and (6) integrative approaches to the carbon cycle. Each cluster of background papers will be coordinated by a member of the project's Science Advisory Committee. Authors of the background papers are welcome to include co-authors, especially co-authors from different areas, but participation in the meeting will be limited to lead authors only.

The product of the meeting will be launched on a fast track schedule. Drafts of the brief background papers will be due December 1, with reviews available by the start of the meeting. Drafts of the synthesis chapters will be completed at the meeting and reviewed within a month of the end of the meeting. Final revisions on the background papers will be due one month after the meeting, and final drafts of the synthesis chapters will be due two months after the meeting. The volume, to be published by Island Press as part of the SCOPE series, should appear within 9 months of the end of the meeting or by November 1, 2003.

## Topics and Authors

### Background Papers (2500-3000 words each)

- Ch 1. Introduction (Chris Field)
- Socio economic drivers (future energy systems and land use) (Rich Richels, coordinator)*
  - Ch 2. Socioeconomic drivers – population, GDP, etc. (Nebojsa Nakicenovic)
  - Ch 3. Fossil fuel emissions and how to reduce them (Jayant Sathaye)
  - Ch 4. Competition for land between urbanization, agriculture, and forestry (Patricia Romero-Lankao)
  - Ch 5. Sociocultural approaches to human drivers (Louis Lebel)
  - Ch 6. Economic aspects of multi-gas perspectives (Rich Richels)
- Engineered sinks (Jerry Melillo, coordinator)*
  - Ch 7. Ocean (biological) (Dorothee Bakker)
  - Ch 8. Land (biological) (Pete Smith)
  - Ch 9. Direct injection (Land and ocean) (Peter Brewer)
  - Ch 10. Non-CO<sub>2</sub> greenhouse gases (Phil Robertson)
  - Ch 11. Ancillary impacts (Jae Edmonds)
- Land (Riccardo Valentini-coordinator)*
  - Ch 12. Carbon transport through commerce – (Jeff Tschirley)
  - Ch 13. Current consequences of past actions (G-J Nabuurs)
  - Ch 14. Biogeochemical drivers of changes in terrestrial ecosystems (Jon Foley)
  - Ch 15. Geographic variation in sensitivity & mechanisms (Dennis Baldocchi)
- Open Ocean (Chris Sabine, coordinator)*
  - Ch 16. Processes regulating uptake in the steady state ocean (Corinne LeQuerre)
  - Ch 17. Processes regulating uptake in the face of climate change and variability (Jorge Sarmiento)
- Fluvial systems and coasts (Niki Gruber, coordinator)*
  - Ch 18. Fluvial systems (Jeff Richey)
  - Ch 19. Coasts (Arthur Chen)
- Overview of the carbon cycle (Chris Field, coordinator)*
  - Ch 20. Current knowledge about spatial and temporal distribution of sources and sinks (Martin Heimann)
  - Ch 21. Paleo perspective (Fortunat Joos)
  - Ch 22. Non-CO<sub>2</sub> greenhouse gases (Ron Prinn)
  - Ch 23. Climate-carbon interactions (Pierre Friedlingstein)

### Synthesis Papers (6000-8000 words each)

- 1) Current status of the carbon cycle, with emphasis on spatial patterns, mechanisms, and interactions: developing the wiring diagram
  - a. New aspects: strong emphasis on broad range of interactions
  - b. Explain the current distribution of sources and sinks
  - c. introduce trajectories, including entrained components, thresholds, and vulnerabilities

- d. uncertainty: pervasive theme through all chapters
  - e. Synthesis chapter team:
    - i. Chair – Mike Raupach
    - ii. Rapporteur -- Chris Sabine (USA, oceans)
- 2) Future trends in the carbon cycle
- a. What are the possible trends without deliberate future intervention?
  - b. What are the entrained trajectories from past management, climate, hydrology, CO<sub>2</sub>?
  - c. Impacts of interactions on a range of time scales
  - d. Synthesis team
    - i. Chair – Detlef Schulze
    - ii. Rapporteur – Patricia Romero-Lankao
- 3) The potential for deliberate management of the carbon cycle
- a. In the context of the full range of current drivers and responses
  - b. Implications and costs of strategies that entail management of land and ocean, in relation to managing fossil fuel (& other human actions)
  - c. policy relevant but not policy prescriptive
  - d. Synthesis team
    - i. Chair – Granger Morgan
    - ii. Rapporteur – Ken Caldeira
- 4) Carbon/Climate/Human Interactions
- a. Link wiring diagram with trajectories and scenarios for possible management
  - b. Explore the ways that the costs and impacts of management change as a function of the status of the rest of the system
  - c. Synthesis chapter
    - i. Chairs – Jerry Melillo
    - ii. Rapporteurs – Philippe Ciais, Riccardo Valentini, and Maria-Jose Sanz

CO2 Stabilization Prerequisites. They also pointed toward a road map for getting there. That is, they combined legal obligations for nations in the two conventions with a variety of 'soft law' principles, guidelines and prescriptions to guide nation-states and others on a wide range of environment and development issues. 13.2 Integrate climate change measures into national policies, strategies and planning. And, it adds 8 other boundaries to offer a more holistic set of suggested environmental markers for humankind to develop within or risk disasterous consequences and irriversible environmental change that may be detrimental for human development. This is a research framework, not a policy framework that has been adopted by UN member states.