

A Workshop Summary

By Rob Coppock and Stephanie Johnson

Board on Agriculture and Natural Resources

Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS Washington, D.C. **www.nap.edu**

Copyright 2004 © National Academy of Sciences. All rights reserved.

To purchase this content as a printed book or as a PDF file go to http://books.nap.edu/catalog/11037.html We ship printed books within 1 business day, personal PDFs are available limited interval subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

> This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

> This workshop was supported under a Task Order Contract #NASW-01008 with the National Aeronautics and Space Administration. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

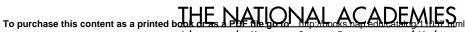
International Standard Book Number 0-309-09226-4 (Book) International Standard Book Number 0-309-53254-X (PDF)

Additional copies of this report are available from the National Academies Press, 500 Fifth Street, N.W., Lockbox 285, Washington, D.C. 20055; (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area); Internet, http://www.nap.edu

Copyright 2004 by the National Academy of Sciences. All rights reserved.

Printed in the United States of America

Copyright 2004 © National Academy of Sciences. All rights reserved.



We ship printed books within 1 business dad pisers to the Wattion on Science Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Wm. A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. Wm. A. Wulf are chairman and vice chairman, respectively, of the National Research Council.

Copyright 2004 © National Academy of Sciences. All rights reserved.

Copyright 2004 © National Academy of Sciences. All rights reserved.

STEERING COMMITTEE FOR A WORKSHOP ON To purchase this content as a printed book or as PRE (1994) DIN DIRE OF HURMAN CONTRIBUTIONS TO We ship printed books within 1 business day; personal PDFs PERRIESTIRTAGIated REENHOUSE GAS FLUXES

MICHAEL J. PRATHER, *Chair*, University of California, Irvine ANN CAMP, Yale University JEANNE NIENABER CLARKE, University of Arizona RUTH S. DEFRIES, University of Maryland JOHN HARRINGTON, JR., Kansas State University RICHARD A. HOUGHTON, The Woods Hole Research Center RATTAN LAL, The Ohio State University IAN ROY NOBLE, The World Bank

Science Writer

ROB COPPOCK, Washington, DC

NRC Staff

JAMIE S. JONKER, Program Officer STEPHANIE JOHNSON, Program Officer TANJA PILZAK, Research Associate MONICA LIPSCOMB, Research Associate ELIZABETH GALINIS, Senior Project Assistant DONNA JAMEISON, Senior Project Assistant

V

Copyright 2004 © National Academy of Sciences. All rights reserved.

BOARD ON AGRICULTURE AND NATURAL RESOURCES To purchase this content as a printed book or as a PDF file go to http://books.nap.edu/catalog/11037.html We ship printed books within 1 business day; personal PDFs are available immediately. MAY BERENBAUM, Chair, University of Illinois at Urbana-Champaign,

Urbana SANDRA BARTHOLMEY, University of Illinois, Chicago DEBORAH BLUM, University of Wisconsin, Madison H. H. CHENG, University of Minnesota, St. Paul W. R. (REG) GOMES, University of California, Oakland ARTURO GOMEZ-POMPA, University of California, Riverside PERRY R. HAGENSTEIN, Institute for Forest Analysis, Planning, and Policy, Wayland, Massachusetts JEAN HALLORAN, Consumer Policy Institute/Consumers Union, Yonkers, New York JANET C. KING, Children's Hospital Oakland Research Center, Oakland, California DANIEL P. LOUCKS, Cornell University, Ithaca, New York WHITNEY MACMILLAN, Cargill, Inc., Minneapolis, Minnesota BRIAN W. MCBRIDE, University of Guelph, Canada TERRY MEDLEY, DuPont Agriculture and Nutrition, Wilmington, Delaware **OLE NIELSEN**, Ontario Veterinary College, Canada **ROBERT PAARLBERG**, Wellesley College, Wellesley, Massachusetts ALICE N. PELL, Cornell University, Ithaca, New York **BOBBY PHILLS, Florida AandM University, Tallahassee** SHARRON S. QUISENBERRY, Virgnia Polytechnic Institute and State University, Blacksburg SONYA B. SALAMON, University of Illinois at Urbana-Champaign, Urbana JACK WARD THOMAS, University of Montana, Missoula B. L. TURNER, Clarke University, Worcester, Massachusetts JAW-KAI WANG, University of Hawaii, Manoa

Staff

CHARLOTTE KIRK BAER, Director KAREN IMHOF, Administrative Assistant

vi

Copyright 2004 © National Academy of Sciences. All rights reserved.

BOARD ON ATMOSPHERIC SCIENCES AND CLIMATE

To purchase this content as a printed bree prove prove of the provide the provided of the provided of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF concernation of the printed books within 1 business day; personal EPF

FREDERICK R. ANDERSON, McKenna Long and Aldridge LLP, Washington, D.C.

ROBERT C. BEARDSLEY, Woods Hole Oceanographic Institution, Massachusetts

ROSINA M. BIERBAUM, University of Michigan, Ann Arbor
RAFAEL L. BRAS, Massachusetts Institute of Technology, Cambridge
MARY ANNE CARROLL, University of Michigan, Ann Arbor
WALTER F. DABBERDT, Vaisala, Inc., Boulder, Colorado
KERRY A. EMANUEL, Massachusetts Institute of Technology, Cambridge
CASSANDRA G. FESEN, Dartmouth College, Hanover, New Hampshire
JENNIFER A. LOGAN, Harvard University, Cambridge, Massachusetts
WILLIAM J. RANDEL, National Center for Atmospheric Research, Boulder, Colorado

ROGER M. WAKIMOTO, University of California, Los Angeles **JOHN C. WYNGAARD,** Pennsylvania State University, University Park

Ex Officio Members

ANTONIO J. BUSALACCHI, JR., University of Maryland, College Park ERIC F. WOOD, Princeton University, Princeton, New Jersey

Staff

CHRIS ELFRING, Director SHELDON DROBOT, Program Officer AMANDA STAUDT, Program Officer JULIE DEMUTH, Research Associate ELIZABETH A. GALINIS, Senior Program Assistant ROB GREENWAY, Senior Program Assistant DIANE GUSTAFSON, Administrative Coordinator ANDREAS SOHRE, Financial Associate

vii

Copyright 2004 © National Academy of Sciences. All rights reserved.

Copyright 2004 © National Academy of Sciences. All rights reserved.

To purchase this content as a printed book or as a PDF file go to http://books.nap.edu/catalog/11037.html We ship printed books within 1 business day; personal PDFs are available in the state of the PDF and the

This workshop summary could not have been produced without the contributions of many individuals who offered their time, expertise, and knowledge. A steering committee planned the workshop. The steering committee members were Michael J. Prather (Chair), University of California, Irvine; Ann Camp, Yale University; Jeanne Nienaber Clarke, University of Arizona; Ruth S. Defries, University of Maryland; John Harrington, Jr., Kansas State University; Richard A. Houghton, Woods Hole Research Center; Rattan Lal, Ohio State University; and Ian Roy Noble, The World Bank. The committee suggested workshop topics, identified speakers, and drafted the workshop agenda. Committee thanks all of the speakers (see Appendixes A and B) and those who attended and contributed to the workshop.

This summary has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We thank the following individuals for their review of this summary: Richard A. Houghton, The Woods Hole Research Center, George Hurtt, University of New Hampshire, James Katzer, ExxonMobil Research and Engineering Company (retired), Dennis Ojima, Colorado State University, Michael J. Prather, University of California, Irvine, and Ron Sass, Rice University

Although the reviewers listed above provided many constructive comments and suggestions, they did not see a final draft of the summary before its release. The review of the summary was overseen by Thomas Graedel of Yale University. Appointed by the NRC, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authors and the institution.

Copyright 2004 © National Academy of Sciences. All rights reserved.

Copyright 2004 © National Academy of Sciences. All rights reserved.



1 Introduction	1
Direct and Indirect Human-Induced Effects on Greenhouse Gases	
Workshop Goals	7
Workshop Summary	. 10
2 Policy Perspective	
Terrestrial Ecosystems, Carbon Stocks, and International Action	. 11
Greenhouse Gas Inventory Systems	. 15
Developing the Capability to Quantify Specific Processes in the	
U.S. Climate Change Science Program	. 17
3 The Science Base for Direct and Indirect Human Contribution to Carbon	
Fluxes	. 19
Direct Human-Induced Effects	. 20
Indirect Human-Induced and Natural Effects	. 28
Partitioning Indirect and Natural Effects from Direct Human-Induced	
Effects	. 34
Data and Analysis Tool Needs	. 40
4 Summary of the State of the Science and Its Policy Implications	. 48
References	. 56

Copyright 2004 © National Academy of Sciences. All rights reserved.

Acronyms and Abbreviations	63
To purchase this content as a printed book or as a PDF file go to http://books.nap.edu/catalog/11037.html	65
To purchase this content as a printed book or as a PDF file go to http://books.nap.edu/catalog/11037.html ADDentitian Argentian available immediately. We ship printed books within 1 business day, bersonal PDFs are available immediately. Appendix B: Steering Committee and Speaker Biographies	69
BANR Publications	

Copyright 2004 © National Academy of Sciences. All rights reserved.

xii