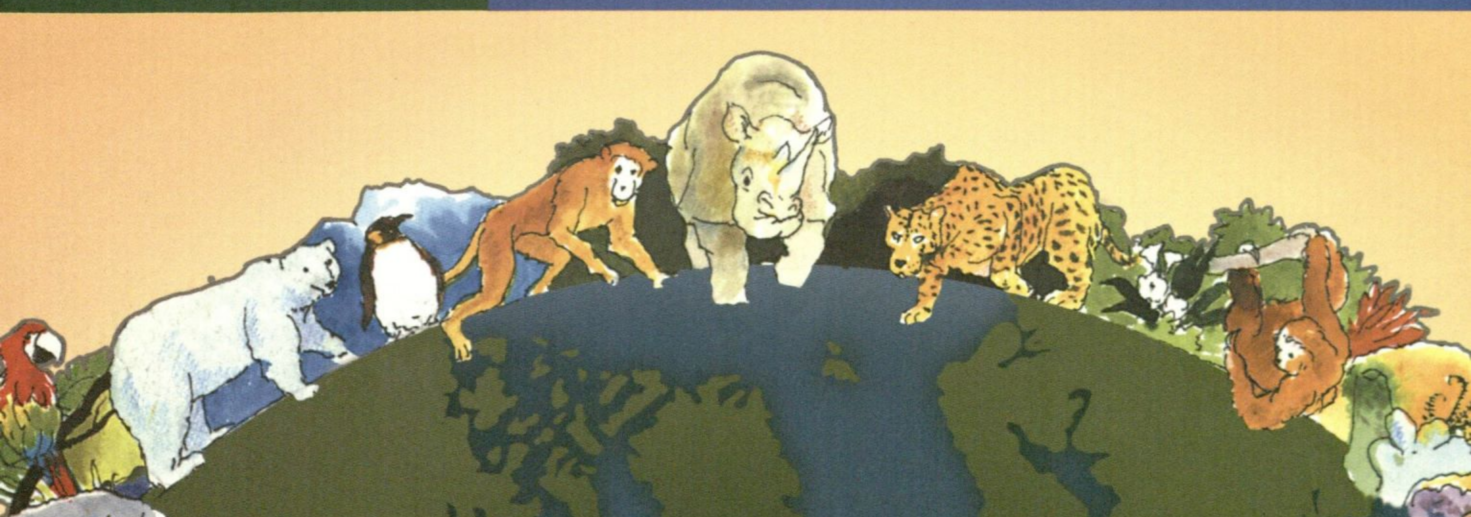
Center for Biodiversity and Conservation

SPRING
SYMPOSIUM

Biodiversity and Climate Change:
Conservation in the Face of Uncertainty

Friday, April 30 – Saturday, May 1, 1999



American Museum of Natural Histo

GEOLOGICAL TIME SCALE

ERA	PERIOD	EPOCH	MILLIONS OF YEARS BEFORE PRESENT	MAJOR EVENTS
Cenozoic	QUATERNARY	Holocene (recent)	0.01	**Sixth major extinction.** Human beings flourish. Many glacial advances and retreats. Variable climate.
		Pleistocene	1.8	
	TERTIARY	Pliocene	5.1	Appearance of hominids. Arid, formation of deserts. Cooler. Climates diversify.
		Miocene	23.7	Spread of grasslands as forests contract. Extensive glaciation in Southern Hemisphere. Moderate climate.
		Oligocene	36.6	Primates, browsing, and marine mammals diversify. Many modern plant genera evolve.
		Eocene	57.8	Modern mammals and birds diversify. Grasslands form. Very warm in early Eocene.
		Paleocene	66.4	Early insectivorous mammals and birds diversify. Mild to cool climate.
Mesozoic	CRETACEOUS		144	**Fifth major extinction.** Age of dinosaurs. Tropical climate with cooling at the end of the period. Angiosperms appear. Insects diversify.
	JURASSIC		208	Birds appear. Warm, stable climate.
	TRIASSIC		245	First dinosaurs and first mammals. Large arid areas. Warm climate.
Paleozoic	PERMIAN		286	**Fourth major extinction.** Reptiles diversify. Worldwide aridity. Cool early in period but progressively warmer. Extensive ice caps.
Carboniferous	PENNSYLVANIAN		330	Amphibians diversify. Gymnosperms and forests appear. First reptiles. Warm, with little seasonal variation.
	MISSISSIPPIAN		360	
	DEVONIAN		408	**Third major extinction.** Fishes diversify. First amphibians. Rise of land plants. Climate cooler.
	SILURIAN		438	**Second major extinction.** First vascular plants, insects and jawed fishes. Mild climate.
	ORDOVICIAN		505	**First major extinction.** Oldest fossil crustaceans. Diversification of mollusks. Extensive glaciation. Mild climate.
	CAMBRIAN		505-590	Evolution of external skeletons. First chordates.
Precambrian	PROTEROZOIC		2500	First eukaryotes: fungi, green algae, and protists.
	ARCHEAN		4600	Origin of life. Prokaryotes, blue-green algae, and bacteria.

RELATIVE TIME SPAN

Sources: *Biology of Plants.* Sixth Edition. Peter H. Raven et al., editors. 1999. NY: Worth Publishers.
Ecology of a Changing Planet. Mark B. Bush. 1997. Saddle River, NJ: Prentice Hall.
A Correlated History of Earth. 1998. Pan Terra, Inc.

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CENTER FOR BIODIVERSITY AND CONSERVATION

SPRING SYMPOSIUM

April 30 and May 1, 1999

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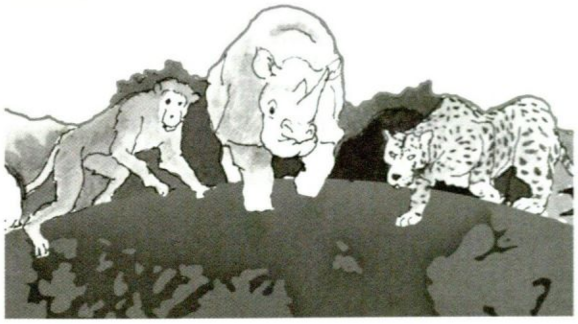
SPRING SYMPOSIUM

Biodiversity is the spectacular variety of life on Earth and the essential interdependence of all living things. Throughout our own evolution, humans have relied on biodiversity for many essential goods, such as food, fuel, fiber, medicines, and countless natural products. Of equal importance are the life-support functions that all life requires, among them purification of air and water, generation and renewal of soil fertility, detoxification and decomposition of wastes, pollination, cycling of nitrogen and other elements crucial to living systems, and moderation of temperature extremes and the forces of wind and waves.



Five major worldwide extinction events have struck at biodiversity since the origin of complex animal life some 535 million years ago. Global climate change and other causes, probably including collisions between the Earth and extraterrestrial objects, were responsible for the mass extinctions of the past. Right now we are in the midst of the Sixth Extinction, this time caused solely by humanity's rapid transformation of the ecological landscape, and affecting a much greater diversity of species. As our population and our demand for resources have exploded, our ability to disrupt, deplete, and destroy natural systems has accelerated. By converting and polluting ecosystems, overexploiting wildlife and fisheries, and transporting alien species across the globe, humanity is presently causing the extinction of many thousands of species a year.

Today global climate change presents a serious threat to biodiversity. The Earth has always experienced change. Species of diverse kinds survived many past climatic cycles by migration or fragmentation of their populations. The predicted rise in temperatures in the coming century, however, will occur in a world transformed by humans. Our virtual elimination of the corridors through which organisms might spread in response to a changing climate, together with the many other factors which have reduced the resiliency of biological communities, magnify the significance of what may appear to be small changes in temperature. Given our complete dependence on biodiversity, it is clear that even in the midst of many uncertainties, we must be prepared to act to address the threat of climate change.

SPRING SYMPOSIUM SCHEDULE

Friday, April 30, 1999

EARTH'S CHANGING CLIMATE

8:15 a.m.	Registration and Coffee
9:00	Welcome and Introduction

Part I	**Climate Change: Understanding the Past**
9:15	Moderator **MICHAEL NOVACEK,** *Provost and Senior Vice-President for Science, American Museum of Natural History*
9:30	Surprise in the Greenhouse **WALLACE S. BROECKER,** *Newberry Professor of Earth & Environmental Sciences, Lamont-Doherty Earth Observatory of Columbia University*
9:50	Rapid Vegetational and Climate Change in the Eastern U.S. and Alaska **DOROTHY PETEET,** *NASA/Goddard Institute for Space Studies and Lamont-Doherty Earth Observatory of Columbia University*
10:10	The Polar Ice Core: Archive of Climate Change **EDWARD BROOK,** *Department of Geology, Washington State University*
10:30	Questions from the Audience
10:45	Coffee Break

Part II	**Climate Change and Extinction: What's the Connection?**
11:00	Moderator **NILES ELDREDGE,** *Curator, Department of Invertebrates, American Museum of Natural History*
11:15	Mass Extinctions and the History of Life **PAUL E. OLSEN,** *Storke Memorial Professor of Earth & Environmental Sciences, Lamont-Doherty Earth Observatory of Columbia University*
11:35	Climate Change and the Fossil Record **JOHN VAN COUVERING,** *Head, Micropaleontology Press, American Museum of Natural History*
11:55	Vertebrate Extinctions and Quaternary Climate Change: Good Connection, Bad Connection, or Missed Connection? **ROSS D. E. MACPHEE,** *Chairman and Curator, Mammalogy, American Museum of Natural History*
12:15 p.m.	The Last Great Warming **SCOTT WING,** *Research Curator, Department of Paleobiology, National Museum of Natural History, Smithsonian Institution*
12:35	Questions from the Audience
12:50	Lunch

SPRING SYMPOSIUM SCHEDULE

Friday, April 30, 1999

Part III	**Is the Earth Warming? A Look at the Evidence**
2:00	Introduction **ELLEN V. FUTTER,** *President, American Museum of Natural History*
2:15	Keynote Presentation **D. JAMES BAKER,** *Under Secretary for Oceans and Atmosphere, U.S. Department of Commerce*
2:45	Questions from the Audience
3:00	Coffee Break

Part IV	**The Impacts of Climate Change on Biodiversity**
3:15	Moderator **ROB DESALLE,** *Associate Curator and Co-Director of the Molecular Laboratories, American Museum of Natural History*
3:30	Nowhere to Run: The Threat of Global Warming to Ecosystems and Species **ADAM MARKHAM,** *Director, Climate Change Program, World Wildlife Fund*
3:50	Global Change and Plant Extinction: How Great Is the Impact? **KENT E. HOLSINGER,** *Professor of Biology, Director, Center for Conservation and Biodiversity, University of Connecticut*
4:10	Insect Response to Climate Change: Evidence from the Quaternary Fossil Record **SCOTT A. ELIAS,** *Fellow, Institute of Arctic & Alpine Research, University of Colorado*
4:30	Unpredictable Effects of Global Climate Change: Coral Bleaching and Coral Disease in the Florida Keys **JAMES W. PORTER,** *University of Georgia*
4:50	Questions from the Audience

SPRING SYMPOSIUM SCHEDULE

Saturday, May 1, 1999

CONSERVING BIODIVERSITY IN THE FACE OF UNCERTAINTY

8:30 a.m.	Coffee

Part V	**Conserving Biodiversity in the Face of Uncertainty**
9:00	Moderator **ELEANOR J. STERLING,** *Program Director, Center for Biodiversity and Conservation*
9:15	The Nature of Conservation: Managing the Dynamic **JOHN G. ROBINSON,** *Vice-President and Director, International Conservation, Wildlife Conservation Society*
9:35	Reefs, Risk and Responsibility: Coral Bleaching and Global Climate Change **PETER O. THOMAS,** *Senior Conservation Officer, U.S. Department of State*
9:55	Conservation Planning for an Unknown Future **DAVID WILCOVE,** *Senior Ecologist, Environmental Defense Fund*
10:15	Questions from the Audience
10:45	Coffee Break

Part VI	**A Local Perspective: Climate Change and the Big Apple**
11:00	Moderator **IRA FLATOW,** *National Public Radio's Talk of the Nation: Science Friday*
11:15	The Baked Apple Scenario **DOUGLAS HILL,** *Consulting Systems Engineer, Regional Plan Association*
11:35	Keeping Cool Heads in a Hothouse World: Climate Change Impacts on New York City **CYNTHIA ROSENZWEIG,** *Research Scientist and Head, Climate Impacts Group, NASA/Goddard Institute for Space Studies*
11:55	The Big Apple's Biodiversity: Prospects for Survival in the Post-Eisenhowerian Era **MICHAEL W. KLEMENS,** *Director, Metropolitan Conservation Alliance, Wildlife Conservation Society*
12:15 p.m.	Questions from the Audience
12:30	Lunch

SPRING SYMPOSIUM SCHEDULE

Saturday, May 1, 1999

Part VII	Where Do We Go from Here?
1:30	Moderator **FRANCESCA T. GRIFO,** *Director, Center for Biodiversity and Conservation*
1:45	Keynote Presentation **FRANK E. LOY,** *Under Secretary of State for Global Affairs*
	Panel Discussion
2:15	**ANTHONY C. JANETOS,** *Senior Vice President for Programs, World Resources Institute*
2:35	**THOMAS E. LOVEJOY,** *Chief Biodiversity Advisor to the President, World Bank*
2:55	**PETER C. FRUMHOFF,** *Director, Global Resources, Union of Concerned Scientists*
3:15	Questions and Concluding Remarks
4:00	Symposium Adjourns

D. James Baker

Under Secretary for Oceans and Atmosphere
Keynote Speaker

Dr. Baker is Administrator of the National Oceanic and Atmospheric Administration (NOAA) and Under Secretary for Oceans and Atmosphere at the U.S. Department of Commerce. In this position, he is responsible for the nation's weather prediction and warning services, environmental satellite and information systems, marine fisheries and coastal zone management, and oceanic and atmospheric research. Dr. Baker is a co-chair of the interagency Committee on Environment and Natural Resources, an ex-officio member of the President's Council on Sustainable Development, and the United States Commissioner to the International Whaling Commission. He previously served as President of Joint Oceanographic Institutions Incorporated; as Dean of the College of Ocean and Fishery Sciences at the University of Washington; as a group leader for Deep-Sea Physics at NOAA's Pacific Marine Environmental Laboratory; and as an associate professor at Harvard University. He is the author of the book *Planet Earth–The View from Space*, and has written extensively about climate, oceanography, and space technology issues.

RELEVANT PUBLICATIONS:

Baker, D. James. 1990. *Planet Earth– The View from Space*. Cambridge, MA: Harvard University Press.

Wallace S. Broecker

Lamont-Doherty Earth Observatory of Columbia University

Surprise in the Greenhouse

Suggestions that the ongoing greenhouse buildup might induce a shutdown of the ocean's thermohaline circulation raise the question as to how the Earth's climate would change if such an event were to occur. The answer preferred by the popular press is that conditions akin to those that characterized the Younger Dryas – the last kiloyear cold snap – would return. But this extreme scenario is an unlikely one, for models suggest that in order to force a conveyor shutdown, Earth would have to undergo a 4 to 5° C greenhouse warming. Hence, the conditions at the very onset of the shutdown would be very different from those that preceded the Younger Dryas. Thus, it is unlikely that new climate conditions would be nearly so severe. Unfortunately, because no atmosphere model to date has been able to create the observed large and abrupt changes in the climatic state of the Earth's atmosphere, we lack even the crudest road map. However, as was the case for each of the abrupt changes recorded in Greenland's ice, if the conveyor were to shut down, climate would likely "flicker" for several decades before locking into its new state. The consequences to agricultural production of these flickers would likely be profound.

Wallace Broecker has spent his entire career studying various aspects of the Earth's climate record and the large-scale circulation patterns in the ocean. His expertise is in isotopic thermometers and chronometers. In 1984, he realized that a strong connection exists between ocean circulation and abrupt changes in climate. Since then he has worked toward a better understanding of how the Earth's climate system accomplished jumps from one state of operation to another and whether such a jump might be triggered by the ongoing buildup of greenhouse gases in the atmosphere.

RELEVANT PUBLICATIONS:

Broecker, W. S. 1999. What if the conveyor were to shut down? Reflections on a possible outcome of the great global experiment. *GSA Today* 9 (January): 1-6.

Broecker, W.S. 1997. Thermohaline circulation, the Achilles heel of our climate system: Will manmade CO_2 upset the current balance? *Science* 278: 1582-1588.

Edward J. Brook
Washington State University

THE POLAR ICE CORE: ARCHIVE OF CLIMATE CHANGE

Cores through the polar ice sheets provide a remarkable archive of past climate conditions and a context for understanding human impacts on climate. They document climate change on time scales as short as a few years and as long as hundreds of thousands of years. Studies of the isotopic composition of the ice, dust content, other impurities, and trapped gases provide a detailed description of major glacial-interglacial changes in the Earth's climate and show clearly the link between changes in climate and biogeochemical cycles over the past 400,000 years. Ice core records also document significant shorter term ("millennial scale") climate change in exquisite detail, showing that the relatively slow pace of glacial-interglacial climate change is not the only mode of variability the Earth is capable of. With respect to the modern situation, records of greenhouse gases are perhaps most significant. These direct measurements of past atmospheric conditions show that current levels of greenhouse gases represent a significant increase above natural levels since the early 1800s, and that both the current concentrations and rates of increase are unprecedented in the past 400,000-plus years.

Edward Brook received a B.S. in Geology from Duke University in 1985, an M.S. in Geology from the University of Montana in 1988, and a Ph.D. in Chemical Oceanography from the MIT/Woods Hole Oceanographic Institution Joint Ph.D. Program in 1993. Subsequently, he was a NOAA Climate and Global Change Postdoctoral Scholar at the University of Rhode Island, and is now an Assistant Professor of Geology and Environmental Science at Washington State University. His current research interests include the history of atmospheric greenhouse gases from ice cores, chronology of northern and southern hemisphere glacial deposits, and development of geochemical tools to study Earth history.

RELEVANT PUBLICATIONS:

Brook, E. J., J. Severinghaus, S. Harder, and M. Bender. In press. Atmospheric methane and millennial scale climate change, in *Mechanisms of Millennial-Scale Global Climate Change*, edited by Webb et al., American Geophysical Union Monograph Series.

Brook, E. J. and T. Sowers. 1996. Rapid variations in atmospheric methane concentration during the past 110 ka. *Science* 273: 1087-1091.

Rob DeSalle
American Museum of Natural History
Moderator

Rob DeSalle received his B.A. in biology from the University of Chicago and his Ph.D in biological sciences from Washington University. He is an associate curator in the Department of Entomology and the co-director of the Molecular Laboratories at the American Museum of Natural History. His research utilizes molecular genetic approaches to examine conservation biology problems.

RELEVANT PUBLICATIONS:

Vogler, A. P. and R. DeSalle. 1993. Diagnosing units of conservation management. *Conservation Biology* 8: 354-363.

DeSalle, R. and B. Schierwater. 1998. *Molecular Approaches to Ecology and Evolution*. Basel: Birkhauser.

Niles Eldredge

American Museum of Natural History
Moderator

Niles Eldredge is Curator in the Department of Invertebrates at the American Museum of Natural History, and Adjunct Professor at the City University of New York. A specialist in mid-Paleozoic phacopid trilobites, his focus is on achieving a better "fit" between historical patterns of stasis and change in the fossil record and evolutionary theory. He has also analyzed the relationship between global extinctions of the geologic past and the present-day biodiversity crisis, as well as the general relationship between extinction and evolution. His ongoing concern is with delineating the differences between gene-centered reductionist evolutionary theory of the "ultra-darwinians" and those who hold evolutionary theory accountable to patterns of historical data. A further aim is to specify the physical, environmental, and large-scale biological systems context of stasis and change in evolutionary history. He has embarked on a new project examining the nature of pattern perception and analysis in the "historical" sciences, and the relative merits of hierarchy versus reductionism in approaching complexity.

RELEVANT PUBLICATIONS:

Eldredge, N. 1998 *Life in the Balance: Humanity and the Biodiversity Crisis.* Princeton, NJ: Princeton University Press.

Eldredge, N. 1998. *Dominion.* New York: Henry Holt and Co.

Scott A. Elias

University of Colorado

INSECT RESPONSE TO CLIMATE CHANGE: EVIDENCE FROM THE QUATERNARY FOSSIL RECORD

The global warming predicted for the next century is not without precedent in recent history. Much of the world experienced temperatures averaging at least 3 degrees Centigrade warmer than those of today during the last interglacial period. Furthermore, the rapid rate of climate change predicted for the 21st century likely also occurred repeatedly in the ancient past. Multiple lines of evidence show that major climatic oscillations at the end of the last glaciation took place within a few decades at most.

Through at least 17 glacial-interglacial cycles over the last two million years, beetle populations responded to large-scale climatic change by shifts in distribution. Few if any extinctions are seen in the Pleistocene fossil beetle record, in contrast to the mammalian fossil record. Looking to the future, however, it is clear that a major environmental factor will come into play that did not exist in the Pleistocene: anthropogenic habitat destruction. Previous (ancient) large-scale climate changes took place against a backdrop of primeval ecosystems. Because of their exceptional dispersal abilities, insects were able to colonize new regions with relative ease. This may not be the case in a world where natural habitats are vanishing concurrent with global warming.

Scott Elias is a Fellow of the Institute of Arctic and Alpine Research at the University of Colorado, Boulder. Since receiving his Ph.D. in 1980, he has studied Quaternary insect fossil assemblages from more than 100 sites in North America and Europe. His main research interests are the paleoecological, paleoclimatic, zoogeographic, and evolutionary implications of insect fossil assemblages. He has developed a research program in the paleoecology of the desert southwest, based on insect fossils from packrat middens. His recent work on the paleoecology of the Bering Land Bridge has helped shed new light on the Pleistocene history of Beringia.

RELEVANT PUBLICATIONS:

Elias, S. A. 1994. *Quaternary Insects and Their Environments.* Washington D. C.: Smithsonian Institution Press.

Elias, S. A., Short, S. K., Nelson, C. H., and Birks, H. H. 1996 Life and times of the Bering land bridge. *Nature* 382: 60-63.

Ira Flatow

National Public Radio's Science Friday
Moderator

As National Public Radio's (NPR) award-winning science correspondent for over 25 years, Ira Flatow has travelled around the world covering everything from Shuttle launches at Cape Canaveral to penguins in Antarctica and a crippled nuclear reactor at Three Mile Island. Flatow currently hosts NPR's "Talk of the Nation: Science Friday" and "Sounds Like Science." His numerous TV credits include six years as host and writer for the Emmy-award-winning "Newton's Apple" on PBS and science reporter for CBS Television's "CBS This Morning." This fall, he will host a PBS special, "Transistorized!," a documentary that chronicles the invention of the transistor. He is news director of the Science and Technology News Network, which delivers science news to local TV stations. He has written articles appearing in many publications, including *Woman's Day* and the *Los Angeles Times.* His most recent book is entitled *They All Laughed...From Light Bulbs to Lasers: The Fascinating Stories Behind the Great Inventions That Have Changed Our Lives* (HarperCollins, New York). It follows on the heels of *Rainbows, Curve Balls and Other Wonders of the Natural World Explained.* Flatow is a board member of the National Association of Science Writers.

RELEVANT PUBLICATIONS:

Flatow, Ira. 1993. *They All Laughed . . . From Light Bulbs to Lasers: The Fascinating Stories Behind the Great Inventions That Have Changed Our Lives.* New York: HarperCollins.

Flatow, Ira. 1989. *Rainbows, Curve Balls and Other Wonders of the Natural World Explained.* New York: HarperCollins.

Peter C. Frumhoff

Union of Concerned Scientists

BUILDING SOLUTIONS TO FORESTS AND CLIMATE CHANGE

The primary cause of climate change is the release to the atmosphere of greenhouse gases that result from the burning of fossil fuels. Effective policies to reduce the threat and severity of climate change must therefore reduce these emissions, particularly in the United States and other industrialized countries. But another important source of greenhouse gas emissions is the ongoing clearing and fragmentation of forests, particularly in tropical countries, a process that is also a globally significant driver of biodiversity loss. Effective policies to conserve and restore these forests can thus help meet both climate change and biodiversity conservation objectives. I will assess emerging opportunities to finance forest conservation and restoration in the tropics through the new Clean Development Mechanism of the climate treaty's Kyoto Protocol.

Peter C. Frumhoff is Director of the Global Resources Program at the Union of Concerned Scientists (UCS). He leads a multidisciplinary effort to bring scientific expertise to bear on U.S. and international policy decisions affecting global environmental change. Prior to joining UCS, Dr. Frumhoff taught at Harvard University and the University of Maryland, and served as a Science and Diplomacy Fellow at the U.S. Agency for International Development. He has published widely on the conservation of biodiversity in tropical forests managed for timber, the scientific and policy linkages between tropical forest conservation and climate change mitigation, the evolution of cooperation and conflict within insect societies, and the behavioral biology of marine mammals. He is a lead author of the Intergovernmental Panel on Climate Change's forthcoming special report on forests and climate, assessing the potential for forest-based climate mitigation projects to provide biodiversity and other sustainable development cobenefits. Dr. Frumhoff is also an Adjunct Associate Professor at the Fletcher School of Law and Diplomacy at Tufts University, where he teaches graduate courses on biodiversity science and policy. Dr. Frumhoff has a Ph.D in Ecology and a M.A. in Zoology from the University of California, Davis. He has a B.A. in Psychology from the University of California, San Diego.

RELEVANT PUBLICATIONS:

Frumhoff, P. C., D. C. Goetze and J. J. Hardner. 1998. *Linking Solutions to Climate Change and Biodiversity Loss through the Kyoto Protocol's Clean Development Mechanism.* Union of Concerned Scientists, Cambridge, MA.

Frumhoff, P. C. and E. C. Losos. 1998. *Setting Priorities for Conserving Biological Diversity in Tropical Timber Production Forests.* Union of Concerned Scientists, Cambridge, MA and Smithsonian Center for Tropical Forest Science, Washington DC.

Francesca T. Grifo

American Museum of Natural History

Moderator

Francesca T. Grifo is Director of the Center for Biodiversity and Conservation at the American Museum of Natural History. She received a Ph.D. in Systematic Botany from Cornell University in 1990, and an A.B. in the Biological Sciences from Smith College in 1981. Her interests center around the conservation of biodiversity, especially how scientific results are best integrated into conservation projects, policy, and education. Dr. Grifo has focused on intellectual property rights and benefits-sharing issues related to the commercialization of biodiversity, including how these and other issues relevant to scientists are interpreted through the Convention on Biological Diversity. Additionally, she has worked closely with an array of institutions in Eastern Europe on national-level biodiversity management and planning. Her recent work has examined the relationships between biodiversity and human health. Dr. Grifo holds an adjunct appointment at Columbia University.

RELEVANT PUBLICATIONS:

Cracraft, J. and F.T. Grifo, editors. In press. *The Living Planet in Crisis.* New York: Columbia University Press.

Grifo, F.T. and J. Rosenthal, editors. 1997. *Biodiversity and Human Health.* Washington, DC and Covelo, CA: Island Press.

Douglas Hill

Regional Plan Association

The Baked Apple Scenario

With global warming, the New York metropolitan region faces worsened summer hot spells, more frequent coastal flooding, and water shortages. Present trends in energy consumption, such as the growing popularity of big, inefficient automobiles, exacerbate the growth in emissions of carbon dioxide. In the long run, the metropolitan area may suffer more from the indirect effects of climate change. Reacting to greenhouse effects may divert capital needed to restore the region's aging infrastructure, contributing to greater inefficiencies in doing business, and less cost-competitiveness in global markets. With its dependence upon international business, the region may also suffer disproportionately from depressed economic conditions overseas due to climate change. As the traditional gateway for immigrants, New York may become overburdened with environmental refugees. With oppressive summer heat, recurring flooding, and strangling traffic congestion, the metropolitan region will become a less attractive place to live. In the near term, there are opportunities to reduce greenhouse gas emissions and take measures to adapt to climate change that will be beneficial regardless of its future severity.

Douglas Hill is a systems engineer, presently a consultant to the Regional Plan Association on climate change issues and to the Energy Technology Systems Analysis Programme of the International Energy Agency. He edited "The Baked Apple? Metropolitan New York in the Greenhouse," the proceedings of a 1994 conference on the local consequences of climate change. He served as a reviewer of the Working Group III Second Assessment report of the Intergovernmental Panel on Climate Change. As a consultant to Brookhaven National Laboratory, he helped develop the MARKAL model of the New York State energy system for projecting energy supply and demand technologies, especially the control of carbon dioxide emissions. Dr. Hill holds degrees of Eng.Sc.D. and M.S. from Columbia University, and B.Aero.Eng. from Rensselaer Polytechnic Institute. He is a licensed professional engineer. He was co-author of the 1990 Long Island Energy Plan prepared for the Long Island Regional Planning Board, and of articles published in the journals *Energy, Energy Policy,* and *Science.*

RELEVANT PUBLICATIONS:

T. Kram and D. Hill. 1996. A multinational model for CO_2 reduction: Defining boundaries of future carbon dioxide emissions in nine countries, *Energy Policy* 24, No. 1.

D. Hill, editor. 1996. *The Baked Apple? Metropolitan New York in the Greenhouse.* Annals of The New York Academy of Sciences 790.

Kent E. Holsinger
University of Connecticut

GLOBAL CHANGE AND PLANT EXTINCTION: HOW GREAT IS THE IMPACT?

Humans have had an enormous impact on our planet. Not only are levels of atmospheric carbon dioxide expected to double in the next 50 years, human activities now dominate most of the world's ecosystems. Global change in the form of habitat destruction and the spread of invasive exotics pose the most immediate threats to the survival of most plant species. The threat posed by global warming is less immediate, but it may be equally severe. Extrapolating patterns of plant movement in response to past climate change suggests that existing nature reserves are mostly too small and too loosely connected to ensure long-term survival of species with narrow ranges. Conservation planners have barely begun to consider the impacts of climate change on design and implementation of strategies to conserve plant biodiversity.

Kent Holsinger's primary research interests are in the evolution and genetics of plant populations. For more than a decade, however, he has used his understanding of basic evolutionary and ecological principles to help solve a variety of conservation problems. He is especially interested in conservation of endangered plant species, and in 1991 he co-edited *Genetics and Conservation of Rare Plants* (Oxford University Press), which is still one of the most highly regarded books in its field. Dr. Holsinger has provided advice to many different local, regional, national, and international conservation groups. In 1992 he was elected to the board of the Connecticut Chapter of The Nature Conservancy, and he has served as a Vice-Chair of the Chapter since 1997.

RELEVANT PUBLICATIONS:

Holsinger, K. E. 1993. The evolutionary dynamics of fragmented plant populations. In *Biotic Interactions and Global Change*, edited by P. Kareiva, J. Kingsolver, and R. Huey, 198-216. Sunderland, MA: Sinauer Associates.

Holsinger, K. E., R. J. Mason-Gamer, and J. Whitton. In press. Genes, demes, and plant conservation. In *Genes, Species, and the Threat of Extinction: DNA and Genetics in the Conservation of Endangered Species*, edited by A. P. Dobson and L. Landweber. Princeton, NJ: Princeton University Press.

Source: Michael E. Mann, Raymond S. Bradley, Malcolm K. Hughes

Anthony C. Janetos
World Resources Institute

CLIMATE CHANGE AND BIODIVERSITY

Many studies of the relationship between climate change and biodiversity have focused on whether or not rapid changes in climate would lead to reductions in diversity. By and large, the results have suggested that rapid changes in climate would have adverse consequences for biological diversity in today's landscape. My focus is on a different aspect of the relationship between these two issues: the degree to which these two environmental issues are intrinsically linked in both their underlying causes and possible solutions.

Many of the driving forces that are endangering the Earth's climate and diversity of life are the same and are due to similar factors in our needs to provide the basic necessities of life. The need to increase agricultural productivity, the need to provide the most basic resources for economic development, and the desires to achieve equitable benefits from the use of natural resources are major contributors both to climate change and to losses of biodiversity. Therefore, the ways in which societies might seek to address these issues also have important common features. One of the many challenges for effective policy action on these critical issues is in fact not to treat them as separate, but to look for actions that achieve synergies.

Anthony Janetos recently joined World Resources Institute as Senior Vice President and Chief of Programs. Previously, he served as Senior Scientist for the Land-Cover and Land-Use Change Program in NASA's Office of Earth Science, and was Program Scientist for the Landsat 7 mission. Dr. Janetos has many years of experience in managing scientific research programs on a variety of ecological and environmental topics, including air pollution effects on forests, climate change impacts, land-use change, ecosystem modeling, and the global carbon cycle. He is currently a Co-Chair of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change, and a lead author in the IPCC Special Report on Land-Use Change and Forestry. Dr. Janetos graduated Magna cum Laude from Harvard University with a bachelor's degree in Biology, and earned a master's degree and a Ph.D. in Biology from Princeton University.

RELEVANT PUBLICATIONS:

Janetos, Anthony C. Do We Still Need Nature?: The Importance of Biological Diversity. *Consequences* 3 (1997): 17.

Watson, R. T., J. A. Dixon, S. P. Hamburg, A. C. Janetos, and R. H. Moss. 1998. *Protecting Our Planet, Securing Our Future: Linkages Among Global Environmental Issues and Human Needs.* United Nations Environment Programme/US National Aeronautics and Space Administration/ The World Bank.

Michael W. Klemens
Wildlife Conservation Society

THE BIG APPLE'S BIODIVERSITY: PROSPECTS FOR SURVIVAL IN THE POST-EISENHOWERIAN ERA

The fauna and flora of the New York metropolitan region evolved in an ever-changing environment. During repeated Pleistocene glaciations, species retreated southward; during inter-glacial periods, plants and animals reinvaded ice-free areas. These oscillations responded to climatic changes in a time scale measured in millennia.

Four hundred years of European colonization caused large-scale habitat changes. Some large mammals were extirpated; many of the lower vertebrates expanded or contracted their ranges. Forest species became rare as land was cleared, yet persisted in small woodlots and steep ravines. When farming moved westward in the nineteenth century, grasslands reverted to forest, forest species re-established themselves, and grassland species became rare. These short-term pulsations occurred over time scales of 50-100 years.

Given such resiliency, does global warming pose a threat to biodiversity? Global warming is not the threat – it is the condition of our landscape that diminishes the resiliency of plants and animals to respond to change. I have coined the term "post-Eisenhowerian Era" to call attention to the radical changes that the 1950's brought to our region's (and our nation's) landscape. Within thirty years, the Eisenhower Interstate Highway System created a fragmented, dysfunctional landscape, first by the direct effect of highway construction, then by spasms of sprawl that moved humans out of compact cities and towns into the hinterlands.

The post-Eisenhowerian landscape is so fragmented that it is a de facto archipelago, subject to the constraints of island biogeography. The changes produced by global warming could have been accommodated through the 1940's. The "hard fragmentation" of post-Eisenhowerian landscapes reduces the ability of most species to migrate in response to habitat change. Solutions to this challenge include re-engineering "hard fragments" into "soft," maintaining biotic corridors in rural and suburban areas, and reinvesting in our cities and towns.

Michael Klemens was born in Australia and educated in the United States and Europe, receiving his doctorate in Conservation Biology and Ecology at the University of Kent in the United Kingdom. He is Director of the Metropolitan Conservation Alliance (MCA) at the Wildlife Conservation Society, a program he began in 1997 to tackle ecosystem loss in the New York City region. A member of the American Museum of Natural History's scientific staff since 1979, he was instrumental in the creation of the Museum's Center for Biodiversity and Conservation.

Dr. Klemens holds professional appointments at Columbia University and at the University of Massachusetts, as well as the Durrell Institute for Conservation and Ecology in the United Kingdom and the lower Hudson Valley. He serves on the World Conservation Union's Species Survival Commission, the Scientific Advisory Board of American Rivers, and as a technical advisor to the Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, NJ Department of Environmental Protection, and the NY State Department of Environmental Conservation.

RELEVANT PUBLICATIONS:

Bogart, J. P., and M. W. Klemens. 1997. Hybrids and genetic interactions of mole salamanders (*Ambystoma jeffersonianum* and *A. laterale*) (Amphibia: Caudata) in New York and New England. *Novitates*, the American Museum of Natural History, NY: 2-16.

Klemens, M. W. 1998. The male nuptial characteristics of *Arthroleptides Martiensseni* Neiden, an endemic torrent frog from Tanzania's eastern Arc Mountains. *Herpetological Journal* 8: 35-40.

Thomas E. Lovejoy

Smithsonian Institution and World Bank

Thomas E. Lovejoy, a tropical biologist and conservation biologist, has worked in the Amazon of Brazil since 1965. He received his B.S. and Ph.D. in Biology from Yale University.

Lovejoy is generally credited with having brought the tropical forest problem to the fore as a public issue. He was the first person to use the term *biological diversity* (in 1980), and made the first projection of global extinction rates in the *Global 2000 Report to the President* that same year. He conceived the idea for the Minimum Critical Size of Ecosystems project, also known as the Biological Dynamics of Forest Fragments Project, which is designed to define the minimum size for national parks and biological reserves. For this work and many conservation initiatives in Brazil, he was decorated by the Brazilian government in 1988, becoming the first environmentalist to receive the Order of Rio Branco. He is also the originator of the innovative concept of debt-for-nature swaps, and the founder of the public television series *Nature*.

From 1973 to 1987 he directed the program of World Wildlife Fund-US, and from 1985 to 1987 served as the Fund's executive vice president. In 1987 he was appointed Assistant Secretary for Environmental and External Affairs for the Smithsonian Institution, and in September 1994 became Counselor to the Secretary for Biodiversity and Environmental Affairs. In 1998 he became Chief Biodiversity Advisor for the World Bank, as well as Lead Specialist for the Environment for the Latin American region. He is past president of the American Institute of Biological Sciences, past chairman of the United States Man and Biosphere Program, and past president of the Society for Conservation Biology.

RELEVANT PUBLICATIONS:

Lovejoy, T. E. 1996. How much is an elephant worth? *Nature*, 382 (6592): 594.

Lovejoy, T. E. 1996. Worldwide Challenges, Hopeful Changes. *American Forester*, 103 (4): 25.

Frank E. Loy

U.S. Department of State
Keynote Speaker

Frank E. Loy was educated in Germany, Italy, and Switzerland, and received his B.A. from the University of California at Los Angeles, and his L.L.B. from Harvard Law School.

Loy was confirmed as Under Secretary of State for Global Affairs in October, 1998. He is responsible for policy regarding international environment and science; population and refugees; the promotion of democracy and human rights, including women's, religious, and labor rights; and counternarcotics and international law enforcement. From 1980 to 1981, he was director of the Department of State's Bureau of Refugee Programs, with the personal rank of ambassador. From 1965 to 1970, he served as Deputy Assistant Secretary for Economic Affairs.

More recently, Mr. Loy served as Chairman of the 1994 International Conference of Parties to the Convention on International Trade in Endangered Species (CITES), as Co-Chair of the Trade and Environment Policy Advisory Committee that advises the United States Trade Representative and the Administrator of the Environmental Protection Agency, and as a member of the United States delegation to the first ministerial conference of the World Trade Organization.

He has been active on the boards of trustees of several nonprofit organizations, including terms as chairman of the Environmental Defense Fund, the League of Conservation Voters, the Washington Ballet, Goddard College, the Foundation for a Civil Society, and Friends of Goethe International.

Ross D. E. MacPhee
American Museum of Natural History

VERTEBRATE EXTINCTIONS AND QUATERNARY CLIMATE CHANGE: GOOD CONNECTION, BAD CONNECTION, OR MISSED CONNECTION?

The "late Quaternary extinctions" (LQE) witnessed, over a 50,000-year period, the loss of hundreds of mammalian and perhaps thousands of bird species. The LQE epoch is broadly analogous to recent times in that it was a period of marked climatic change. But were any of the LQE caused by climate change, and, if so, how could we tell? Recent evidence suggests that, in the New World, most losses occurred within a 400-year envelope ca. 12,000 years ago – except in the West Indies, where losses began to occur some 5,000 years later. The West Indian extinctions precisely correlate with the earliest evidence of human presence. Extremely rapid losses immediately subsequent to human first contact are now known to have been the rule in Polynesia, Madagascar, Australia, and elsewhere. The present consensus seems to be that there is no case in which "climate change" by itself explains any LQE, whereas human first contact can be used to explain virtually all of them.

Although at present the principal consequence of "global warming" is climatic, its root cause is conceived to be anthropogenic. However, if the late Quaternary analogy is meaningful, a 2-5° C change by itself is not going to result in widespread extinction among terrestrial vertebrates because wider fluxes than that occurred without causing losses (e.g., late Pleistocene Australia). If losses do occur in future, they will be largely the result of other human impacts that have already removed much of the resilience in Earth's biotas.

Ross D. E. MacPhee received his Ph.D. in Physical Anthropology from the University of Alberta in 1977, and was previously Associate Professor of Anatomy at Duke University Medical Center. Since 1988 he has been Curator and, since 1993, Chairman of the Department of Mammalogy at the American Museum of Natural History. He is known for his paleomammalogical research on island extinctions, particularly in Madagascar and the West Indies. His recent work concerns how extinctions occur, particularly those in which humans have been implicated. His books and monographs include *Extinctions in Near Time: Causes, Contexts, and Consequences* (editor), and *Primates and their Relatives in Phylogenetic Perspective* (editor). He has published more than 70 papers in various journals, including the *Journal of Vertebrate Paleontology, American Journal of Physical Anthropology, Nature, Science, American Museum Novitates, Journal of Human Evolution, Palaeontology, International Journal of Primatology*, and *Journal of Archaeological Science*. He is a Fellow of the American Association for the Advancement of Science and a member of several scientific societies.

RELEVANT PUBLICATIONS:

MacPhee, R. D. E., and P. A. Marx. 1997. The 40,000-year plague: Humans, hyperdisease, and first-contact extinctions. In *Natural Change and Human Impact in Madagascar*, edited by S. M. Goodman and B. D. Patterson, 169-217. Washington, DC: Smithsonian Institution Press.

MacPhee, R. D. E. and C. Flemming. 1999. Requiem Aeternum: The last five hundred years of mammalian species extinctions. In *Extinctions in Near Time: Causes, Contexts, and Consequences*, edited by MacPhee, R. D. E., 333-372. New York : Kluwer Academic/Plenum Publishers.

Source: Michael E. Mann, Raymond S. Bradley, Malcolm K. Hughes

Adam Markham
Climate Change Program, World Wildlife Fund

NOWHERE TO RUN: THE THREAT OF GLOBAL WARMING TO ECOSYSTEMS AND SPECIES

The evidence is mounting that we are experiencing a worsening trend of global warming resulting mainly from emissions of carbon pollution to the atmosphere from the burning of fossil fuels such as coal and oil. Global warming poses a major threat to many of the world's wildlife species and their habitats. Tropical cloud forests, alpine meadows, prairie wetlands, low-lying coastal areas and coral reefs may be especially sensitive to change. Ecosystems near the poles, including Arctic tundra and boreal forest, are deemed to be at particular risk because of the greater expected warming at higher latitudes. Computer models used to project possible future climate scenarios indicate that more than a third of the world's existing protected areas are likely to experience significant change in a warming world.

Indications already exist that the warming trend of the last few decades is beginning to have an impact. Glaciers are melting world-wide and sea-ice is thinning in the western Arctic. Many species, including some butterflies, plants and seashore animals, are being recorded moving to higher latitudes or altitudes in response to the warming. With an earlier onset of spring in the northern hemisphere, migratory birds are arriving to breed earlier in the Great Lakes region and in northern Europe. Each species will react differently and respond to climate change at different rates, so ecosystems will not be able to move wholesale in response to change. Some ecosystems may be lost entirely, and others will be much reduced in extent. Global warming presents a major challenge to conservationists, and should be given priority in planning to protect biodiversity into the next millennium and beyond. Because the most vulnerable systems will often be those that are most under stress or fragmented already, current efforts to preserve habitat should be increased in order to help buffer the impacts of climate change.

A native of Great Britain, Adam Markham has worked for the World Wildlife Fund for twelve years, first in Switzerland, and since 1993, in Washington, D.C. Originally trained as a zoologist at the University College of Swansea in Wales, he currently directs WWF's international climate change program. He has worked as a journalist, writing about arts and environmental issues, and is currently working on a book about the impacts of global warming on U.S. national parks. He is the author of *A Brief History of Pollution*, published by St. Martin's Press, and recently edited a volume of papers on the *Potential Impacts of Climate Change on Tropical Forest Ecosystems* (Kluwer Academic Publishers).

RELEVANT PUBLICATIONS:

Markham, A. 1996. Potential impacts of climate change on ecosystems: A review of implications for policymakers and conservation biologists. *Climate Research* 6: 179-191.

Markham, A. and J. R. Malcolm. 1996. Biodiversity and wildlife conservation: Adaptation to climate change. In *Adapting to Climate Change: Assessments and Issues*, J. B. Smith, N. Bhatti, G. Menzhulin, R. Benioff, M. I. Budyko, M. Campos, B. Jallow, and F. Rijsberman, editors. New York: Springer.

Michael Novacek

American Museum of Natural History

Moderator

Michael Novacek has served since 1982 as Curator at the American Museum of Natural History. Since 1989 he has also served as Vice President and Dean of Science and, since 1995, as Senior Vice President and Provost of Science. Awarded a doctoral degree (with honors for outstanding graduate research) at the University of California, Berkeley, in 1978, his studies concern paleontology and evolutionary and systematic biology. In the course of his investigations he has established an international field program as leader of expeditions to Baja California, Mexico, the Andes Mountains of Chile, the Yemen Arab Republic, and Gobi Desert of Mongolia. The Mongolian expeditions, which mark the first return of a western scientific team to the country in over sixty years, have recovered an extremely rich assemblage of dinosaurs, ancient mammals, and other fossil vertebrates. Novacek is the author of more than 140 titles, including articles in the international scientific journals *Science* and *Nature*. His research has been widely acknowledged by the scientific community, the popular press, and the media. He has also served as the President of the Society of Systematic Biologists and as a member of the Board of Directors of the American Association for the Advancement of Science (AAAS).

RELEVANT PUBLICATIONS:

Novacek, M. J. 1996. *Dinosaurs of the Flaming Cliffs*. New York, London: Anchor Books, Doubleday.

Novacek, M. J. 1997. Mammalian evolution: an early record bristling with evidence. In *Current Biology* 7: R489-491.

Paul E. Olsen

Lamont-Doherty Earth Observatory of Columbia University

MASS EXTINCTIONS AND THE HISTORY OF LIFE

Extinction is the fate of nearly all species. However, the geological record shows six intervals of concentrated extinction that stand as landmarks in life's history. The oldest two are so ancient that it is hard to gauge their magnitude or cause. The next three are: the end-Permian mass extinction 250 million years ago, the largest of all the extinctions; the end-Triassic event 202 million years ago, after which dinosaurs became the dominant land animals; and the end-Cretaceous mass-extinction 65 million years ago, which marked their demise. These three extinctions appear to have been caused by dramatic environmental change. This is known in greatest detail and certainty for the end-Cretaceous event, which was apparently caused by the impact of a giant asteroid or comet. An asteroid is also implicated for the end-Triassic event; however, all three mass extinctions also appear synchronous with giant, terrestrial volcanic events – a coincidence too grand to be accident. In contrast, the most recent mass-extinction event has occurred during the last 50,000 years and appears to be ongoing. Unlike the extrinsic, non-biological origin of the previous events, this mass extinction coincides with the spread of a new species, Homo sapiens, *and its associated technology.*

Paul Olsen's overall focus is on the evolution of continental ecosystems, especially the pattern, causes and effects of climate change on geological time scales, mass extinctions, and the effects of evolutionary innovations on biogeochemical cycles. Recent projects include: 1) drilling and study of 22,600 feet of core from 210-million-year-old lake beds to understand the influence of variations of the Earth's orbit on climate; 2) analysis of the mass extinction 202 million years ago that set up dinosaurian dominance; 3) excavations at major fossil vertebrate sites throughout eastern North America and Morocco; and 4) the evolutionary events mediating the carbon cycle.

RELEVANT PUBLICATIONS:

Olsen, P. E. 1997. Stratigraphic record of the early Mesozoic breakup of Pangea in the Laurasia-Gondwana rift system. In *Annual Reviews of Earth and Planetary Science* 25: 337-401.

Olsen, P. E. and D.V. Kent. 1996. Milankovitch climate forcing in the tropics of Pangea during the Late Triassic. In *Palaeogeography, Palaeoclimatology, and Palaeoecology* 122: 1-26.

Dorothy Peteet
NASA/Goddard Institute for Space Studies and Lamont-Doherty Earth Observatory of Columbia University

RAPID VEGETATIONAL AND CLIMATE CHANGE IN THE EASTERN UNITED STATES AND ALASKA

How quickly has climate changed in the past? Did climate change happen simultaneously around the world? One way to investigate such questions is through study of the remains of plants in lakes and bogs. Seeds, needles, pollen and other plant parts are very well preserved in lake muds because of the lack of oxygen in the sediments. From careful analysis and precise timing of many sediment records, we now know that since the last ice age (21,000 years ago), the climate has experienced at least one major climatic reversal to cold conditions. Our research over the last decade shows that the climate flipped rapidly in the northeastern U.S., where a warm mixed boreal-hardwood forest was replaced within 100 years by a cold boreal forest. The flip back to warm conditions was even more rapid, occurring within 50 years. Investigations on Kodiak Island, Alaska, reveal that the climate there also reversed rapidly at the same time, and a lush green coastal environment changed to a cold, dry tundra for about a thousand years. Do other continents reveal this change? Our final goal is to understand why these dramatic changes happened in order to better understand our climate system.

Dorothy Peteet is a Quaternary paleoecologist and paleoclimatologist. Her expertise is palynology and macrofossil investigations, which are used to reconstruct vegetational and climatic history. Dr. Peteet's research is focused in the eastern U.S. as well as the Arctic and subarctic (Alaska and Siberia). Rates of tree migration, wetland carbon histories, and rapid climate change are special topics of research. General circulation modeling (GCM) is utilized to perform climate sensitivity tests in order to better understand mechanisms and causes of climatic change.

RELEVANT PUBLICATIONS:

Kneller, M. and D. Peteet. 1999. Late-glacial to early Holocene climate changes from a central Appalachian pollen and macrofossil record. *Quaternary Research* 51 (2): 133-147.

Peteet, D. M., A. Del Genio and K. K. Lo. 1997. Sensitivity of Northern Hemisphere air temperatures and snow expansion to N. Pacific sea surface temperatures in the *GISS GCM. Journal of Geophysical Research* 102: 781-791.

Peteet, D. M. and D. H. Mann. 1994. Late-glacial vegetational, tephra, and climatic history of southwestern Kodiak Island, *Alaska Ecoscience* 1(3).

James W. Porter
University of Georgia

UNPREDICTABLE EFFECTS OF GLOBAL CLIMATE CHANGE: CORAL BLEACHING AND CORAL DISEASE IN THE FLORIDA KEYS

Corals, like most tropical marine organisms, are much closer to their upper lethal temperature than to their lower lethal temperature. As a result, global warming has brought a variety of unwanted stresses to coral reefs. Some reefs in the Florida Keys are experiencing a substantial loss of coral cover and biodiversity due to coral bleaching (the loss of their beneficial symbiotic algae caused by elevated water temperatures), and to disease (caused by a host of new pathogens). During extensive surveys throughout the Keys there has been a quadrupling of the number of stations exhibiting disease and a tripling of the number of coral species afflicted by disease. One locality, the deep (20m) reef at Carysfort Light, has experienced a 62% reduction of living coral cover during the three-year survey. Similar stresses from other marine environments create a chaotic pattern of response as natural environments respond to global climate change.

James W. Porter is Professor of Ecology and Marine Sciences at the University of Georgia. He received his B.S. from Yale in 1969 and his Ph.D. from Yale in 1973. After teaching at the University of Michigan from 1973 to 1997, he joined the faculty in the Institute of Ecology at the University of Georgia. He has testified before Congress three times, most recently on coral reef conservation and the effects of global climate change on coral reefs. Currently he is collaborating with the U.S. Environmental Protection Agency on long-term monitoring of coral reefs, studying the distribution and abundance of corals and coral disease from Key Largo to the Dry Tortugas.

RELEVANT PUBLICATIONS:

Cervino, J. M., T. J. Goreau, R. L. Hayes, L. Kaufman, I. Nagelkerken, K. Patterson, J. W. Porter, G. W. Smith, and C. Quirolo. 1998. Coral Diseases. *Science* 280: 99-500.

Porter, J. W., S. K. Lewis, and K. G. Porter. In press. The effect of multiple stressors on the Florida Keys coral reef ecosystem: A landscape hypothesis and a physiological test. *Limnology and Oceanography.*

John G. Robinson
Wildlife Conservation Society

THE NATURE OF CONSERVATION: MANAGING THE DYNAMIC

The nature of conservation has changed with the realization that the "nature" we seek to conserve is itself constantly changing and variable. No longer can we assume that natural systems are ordered and stable. This creates a challenge to those who seek to conserve natural systems within parks and reserves. How do you manage dynamic natural communities within parks, and for what do you manage? The challenge is compounded if climate change introduces additional pressure on parks, affecting the survival of individual species and the composition of the whole biological community. This presentation explores the utility of landscape approaches to conserve biological systems, which are themselves dynamic, in a world whose overall climate is also changing.

John G. Robinson is Vice-President and Director of the International Conservation programs of the Wildlife Conservation Society (WCS). As well as overseeing the Society's more than 300 projects in 55 countries in Africa, Asia and the Americas, Dr. Robinson continues to explore how human uses of tropical forests affect their biodiversity and long-term survival. He is well known for his work in tropical conservation, and has undertaken field work in Colombia, Venezuela, Peru, and Brazil. Dr. Robinson has over 100 publications to his credit.

RELEVANT PUBLICATIONS:

Redford, K. and J. G. Robinson, editors. 1991. *Neotropical Wildlife Use and Conservation.* Chicago: University of Chicago Press.

Bennet, E. and J. G. Robinson. In press. *Hunting for Sustainability in Tropical Forests.* New York: Columbia University Press.

Cynthia Rosenzweig

NASA/Goddard Institute for Space Studies

KEEPING COOL HEADS IN A HOTHOUSE WORLD: CLIMATE CHANGE IMPACTS ON NEW YORK CITY

The New York City region is the quintessential urban agglomeration in the United States, with nearly 20 million people, or 7 percent of the nation's population. Currently, it is the fourth largest urban center in the world. How this region will respond to the challenges of global change may be seen as a bellwether for other large cities. The urgency stems from the rapid rate of global urbanization and growth in number of large-scale urbanized regions worldwide. The number of cities with one million or more residents is projected to increase from 782 in 1990 to 1,657 in 2015.

Three interacting elements of New York City react and respond to climate variability and change: people (socio-demographic conditions), place (physical systems), and pulse (decision-making and economic activities). To understand these elements, five sector studies are projecting climate change impacts: Coastal Zone, Infrastructure, Water Supply, Public Health, and Institutional Decision-making. Each study is assessing potential climate change impacts through the analysis of the current conditions in the region, lessons and evidence derived from past climate variability, scenario predictions, critical issues, equity of impacts, potential non-local interactions, and policy recommendations.

Cynthia Rosenzweig is a research scientist at the National Aeronautic and Space Administration (NASA) Goddard Institute for Space Studies, where she is the leader of the Climate Impacts Group. The mission of the group is to investigate the interactions of climate with systems and sectors important to ecological and human well-being. Dr. Rosenzweig is currently leading the Metropolitan East Coast Region for the U.S. National Assessment of Climate Variability and Change. She is an Adjunct Research Scientist at the Columbia University Earth Institute and an Adjunct Professor at Barnard College, with degrees from Rutgers University and the University of Massachusetts. Her research focuses on the impacts of environmental change, including increasing carbon dioxide, global warming, and El Niño, on regional, national, and global scales.

RELEVANT PUBLICATIONS:

Rosenzweig, Cynthia and William D. Solecki. 1999. *Climate Change and A Global City: An Assessment of the Metropolitan East Coast Region. Climatic Change* (in preparation).

Rosenzweig, Cynthia and Daniel Hillel. 1998. *Climate Change and the Global Harvest: Potential Impacts of the Greenhouse Effect on Agriculture.* New York: Oxford University Press.

Eleanor Sterling

American Museum of Natural History
Moderator

Dr. Sterling develops and coordinates international field projects and oversees education activities for the Center for Biodiversity and Conservation at the American Museum of Natural History. She earned her Ph.D. in Anthropology and Forestry and Environmental Studies at Yale University. She has spent more than ten years in Africa, Asia and Latin America, undertaking field research projects on the ecology and conservation of primates and other mammals. In addition, Sterling has developed national and international environmental education programs, also serving as a trainer and consultant. She has worked for several international conservation organizations in both the United States and Africa, and has trained teachers, students, and U.S. Peace Corps Volunteers in biodiversity conservation and environmental education.

RELEVANT PUBLICATIONS:

Gibbs, James, Malcolm Hunter, and Eleanor J. Sterling. 1998. *Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory.* Malden, MA: Blackwell Science.

Wyner Y., R. Absher, G. Amato, E. Sterling, R. Stumpf, Y. Rumpler, and R. DeSalle. In press. Species concepts and the determination of historic gene flow patterns in the *Eulemur fulvus* (Brown Lemur) complex. *Biological Journal of the Linnean Society.*

Peter O. Thomas

U.S. Department of State

Reefs, Risk and Responsibility: Coral Bleaching and Global Climate Change

In March 1999, a Department of State report concluded it was likely that anthropogenic global warming contributed to the extensive coral bleaching and mortality that occurred simultaneously throughout the disparate reef regions of the world in 1998. The geographic extent, increasing frequency, and regional severity of mass bleaching events are a likely consequence of a steadily rising baseline of marine temperatures. Even under the best of conditions, many of these coral reef ecosystems will need decades to recover. Human populations dependent on reef services face losses of marine biodiversity, fisheries, and shoreline protection. Trends of the past century suggest that coral bleaching events may become more frequent and severe as the climate continues to warm, exposing coral reefs to an increasingly hostile environment. This global threat to corals places greater urgency on our efforts to manage the entire range of human-induced threats to reefs, including climate change. Coral reefs are projected to be among the most sensitive ecosystems to long-term climate change; their response may foreshadow climate impacts on other ecosystems. Natural resource management agencies must consider their role in drawing attention to the predicted impacts of global climate change on the resources they manage. Even ecosystems granted well-enforced legal protection such as parks, sanctuaries, or sustainable areas may be made vulnerable by global climate change.

Peter Thomas received his doctorate in Animal Behavior from the University of California, Davis, in 1987 and came to the Department of State in 1991 as an AAAS Fellow. Since the Rio Earth Summit, he has been responsible for U.S. policy on the Convention on Biological Diversity and has led numerous U.S. delegations to meetings of this body. He was Global Coordinator for the International Coral Reef Initiative from June 1995 to August 1996, and remains the primary U.S. focal point for the initiative. He represents the State Department on the U.S. Coral Reef Task Force and The Task Force on Amphibian Declines and Deformities.

RELEVANT PUBLICATIONS:

Pomerance, Rafe, Jamie Reaser and Peter Thomas. 1999. Coral bleaching, coral mortality, and global climate change. *U.S. Department of State Report.*

Source: Michael E. Mann, Raymond S. Bradley, Malcolm K. Hughes

John A. Van Couvering
American Museum of Natural History

Climate Change and the Fossil Record

Climate change in the fossil record is documented not only by evidence of habitat shifts (extinction, migration, diversification), but also by subtle variation in the isotopic balance in common elements, such as carbon and oxygen, that are part of the fossil's substance. Tracing isotopic variations in the deep sea where the microfossil record is an uninterrupted "tape recorder" has revealed periodic changes in world climate due to the complex "beat" of interfering cycles in the Earth's axial tilt, the orientation of the axis in space, and the shape of the orbit. In the past 10 years, the mathematically precise climatic imprint of the orbital clock on the microfossil tape recorder has revolutionized the measurement of geological time. In addition, orbitally forced insolation cycles are superimposed on long-term geological trends that change the sensitivity of the Earth's weather to the orbital influences. The present configuration of continental plates guarantees climatic instability, such that the world will remain in its present "ice house" stage, with cyclic waves of glacials and interglacials, for many millions of years before normal "greenhouse" conditions return. The approach to "ice house" since the end of the Paleocene, 45 million years ago, can be seen in progressive adaptations of the world biota to increasingly strong seasonal differences.

John Van Couvering was trained as a field geologist at UCLA, and did his dissertation at Cambridge University, unravelling the stratigraphy and age of Miocene (18-million-year-old) hominid fossils on Rusinga Island, Kenya, under Louis S. B. Leakey. At the famous geophysics lab in Cambridge, doing work on radiometric dating of the Rusinga fossil beds, he shared in the excitement as plate tectonics was born. He became involved with micropaleontology through his work on the geologic time scale, and has also continued to study the history of African fossil mammals, but has never learned to identify a fossil. He has been head of Micropaleontology Press since 1978.

Relevant Publications:

Tattersall, I., E. Delson, and J. A. Van Couvering. 1988. *The Encyclopedia of Human Evolution.* New York, Garland Press.

David Wilcove
Environmental Defense Fund

Conservation Planning for an Unknown Future

Global climate change occurs against a backdrop of other human-created stresses on biodiversity. Foremost among these are the loss and fragmentation of natural ecosystems and the spread of invasive species. To counteract the potential impacts of climate change, scientists have suggested that reserves be linked together by habitat corridors; that the reserve system be expanded to incorporate a wider range of latitudes; and that, wherever possible, reserves be situated along altitudinal gradients, so that species can move in response to changing climate. Unfortunately, ongoing habitat destruction, coupled with the spread of alien species, is likely to limit the possibility of following any of these recommendations. Given differences in topography and land ownership, efforts to create reserve networks capable of withstanding global climate change are likely to be more successful in the western United States than in the East.

David Wilcove
(Continued)

David Wilcove is a senior ecologist at the Environmental Defense Fund in Washington, DC, where he develops science-based strategies to protect endangered species. He is the author of *The Condor's Shadow: The Loss and Recovery of Wildlife in America* (1999), as well as numerous technical and popular articles in the fields of conservation biology, ornithology, and endangered species protection. He has served on the boards of directors of the Society for Conservation Biology and the RARE Center for Tropical Conservation, as well as the editorial boards of *Conservation Biology, Ecological Applications,* and *New England Naturalist*. In 1990, Dr. Wilcove was one of ten scientists awarded a Pew Scholarship in Conservation and the Environment. Dr. Wilcove previously worked for The Wilderness Society and The Nature Conservancy. He received a Ph.D. in Biology from Princeton University and a B.S. from Yale University.

RELEVANT PUBLICATIONS:

Wilcove, D. S. 1999. *The Condor's Shadow: The Loss and Recovery of Wildlife in America.* New York: W.H. Freeman.

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Scott Wing
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THE LAST GREAT WARMING

There are no recent precedents for the rapid warming anticipated over the next 100 years, but there are examples in the geological past. Studying the fossil record is the one way we can investigate the effects of global climate change without waiting for it to happen. Fossils can be used both to test predictions made by computer models of global climate, and to gauge the effect of climatic warming on biological diversity and ecological structure.

Fifty-five million years ago at the beginning of the Eocene epoch, palm trees grew in Montana, even though North America was farther north than it is today. Scientists have simulated Eocene climatic conditions with the same models used to predict future climate change, but the model-based winter temperatures are unable to match the equable climatic conditions that fossils document. This raises the question: if they can't predict the past, how accurate are their projections for the future?

We can also use the fossil record to study the effects of temperature increase on ecosystems. Geologists have identified a short interval of very rapid warming almost exactly 55 million years ago. Although the causes are still poorly understood, paleontologists have seen the results in everything from mass extinction of unicellular marine species to the intercontinental migration of mammals. The past is an important testing ground for our models of climate dynamics and the response of organisms to climate change.

Scott Wing was born in New Orleans and grew up there and in Durham, North Carolina. He became interested in fossils through field work in Wyoming while an undergraduate at Yale, where he received his B.S. in Biology in 1976. He completed his Ph.D. in Biology at Yale in 1981, and then was a National Research Council Fellow at the U.S. Geological Survey. He went to the Smithsonian Institution in 1984, where he has continued his research on floral change, paleoecology and paleoclimatology of the late Cretaceous and early Cenozoic. He is a Research Curator in the Department of Paleobiology.

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Source: Michael E. Mann, Raymond S. Bradley, Malcolm K. Hughes

Aerosols
Particulate matter suspended in the atmosphere that reflects light back into space, with a cooling effect.

Atmosphere
The gases surrounding the Earth, consisting of nitrogen, oxygen, carbon dioxide, and trace amounts of other gases. There are four atmospheric layers: the troposphere, the stratosphere, the mesosphere, and the ionosphere.

Biodiversity
The spectacular variety of life on Earth and the essential interdependence of all living things.

Biosphere
The region on land, in the oceans, and in the atmosphere inhabited by living organisms.

Carbon cycle
The global-scale exchange of carbon among its reservoirs, namely the atmosphere, oceans, vegetation, soils, and geologic deposits and minerals.

Carbon dioxide (CO_2)
The greenhouse gas whose concentration is being most affected directly by human activities. The major source of CO_2 emissions is fossil fuel combustion; forest clearing, biomass burning, and non-energy production processes such as cement production can also release CO_2.

Carbon sequestration
The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen, and store the carbon. Fossil fuels were at one time biomass, and continue to store carbon until burned.

Carbon sinks
Carbon reservoirs that take in and store more carbon than they release. Carbon sinks can serve to partially offset greenhouse gas emissions. Forests and oceans are important carbon sinks.

Climate
The average pattern of weather for a particular region over time (usually measured over a 30-year period). Climate is not the same as weather, which describes the short-term state of the atmosphere.

Climate change (also 'global climate change')
The term "climate change" is sometimes used to refer to all forms of climatic inconsistency, but because the Earth's climate is never static, the term is more properly used to imply a significant change from one climatic condition to another. In some cases, "climate change" has been used synonymously with "global warming"; scientists, however, tend to use the term in the wider sense to also include natural changes in climate.

Climate models
Quantitative ways of representing the interactions of the atmosphere, oceans, land surface, and ice.

Climate system
The atmosphere, the oceans, the biosphere, the cryosphere, and the geosphere together make up the climate system.

Deforestation
Converting forested lands to nonforest uses; clearing forests by logging, burning, or otherwise removing trees. A contributor to the greenhouse effect, since burning trees releases carbon dioxide into the atmosphere, and trees that once removed and sequestrated carbon dioxide can no longer perform those functions.

Dendrochronology
The study of annual rings in trees to determine dates and environmental conditions in the past.

El Niño
Seasonal changes in the direction of the tropical winds over the Pacific, accompanied by abnormally warm surface ocean temperatures; these changes can disrupt weather patterns throughout the tropics. The relationship between these events and global weather patterns is currently being studied.

Fluorocarbons (CFCs, HCFCs, HFCs)
Chlorofluorocarbons (CFCs) and related compounds, including bromofluorocarbons (halons), methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds have been shown to deplete stratospheric ozone, and are therefore referred to as ozone-depleting substances.

Fossil fuels
Combustible geologic deposits of carbon in organic form, including coal, oil, and natural gas. They emit carbon dioxide into the atmosphere when burned, contributing to the greenhouse effect.

Global average surface temperature
The average world temperature as determined by measurements taken in many different parts of the globe. Over the past 100 years, the global average surface temperature has risen by 0.8 to 1.0 degrees F.

Global warming
An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases.

Greenhouse effect
The natural process by which certain gases in the Earth's atmosphere absorb heat radiating from the Earth's surface and re-emit some of that heat back toward Earth.

Greenhouse gases
Gases in the atmosphere, including carbon dioxide, methane, nitrous oxide, ozone, water vapor, and others, that absorb and "trap" heat in the Earth's atmosphere. Carbon dioxide is considered to be the most important greenhouse gas.

Ice core
A cylindrical section of ice removed from a glacier or an ice sheet in order to study climate patterns of the past. By performing chemical analyses on the air trapped in the ice, scientists can estimate the percentage of carbon dioxide and other trace gases in the atmosphere at that time.

Methane
A greenhouse gas, methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and oil, coal production, and incomplete fossil fuel combustion.

Milankovitch cycles
Variations in the Earth's orbit around the sun, which affect global seasonality.

Nitrous oxide (N_2O)
Nitrous oxide is a powerful greenhouse gas. Sources include commercial and organic fertilizers, fossil fuel burning, and biomass burning.

Ozone (O_3)
An important greenhouse gas, ozone has other effects. In the stratosphere, ozone provides a protective layer shielding the Earth from ultraviolet radiation. In the troposphere, oxygen molecules in ozone combine with other chemicals and gases to form smog.

Paleoclimatology
The study of past climates.

Paleoecology
The study of past ecosystems.

Renewable energy
Energy from sources that can regenerate themselves, such as solar energy, hydro energy, wind power, or biomass energy.

Weather
Weather is the specific condition of the atmosphere at a particular place and time.

Source: Michael E. Mann, Raymond S. Bradley, Malcolm K. Hughes

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ADAPTED FROM: The Environmental Protection Agency Global Warming Website glossary, at http://www.epa.gov/globalwarming/glossary.html.
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Many of these titles are available in the Museum Shop.

SUGGESTED RESOURCES

WEBSITES

American Geophysical Union
http://www.agu.org/sci_soc/sci_soc.html

Center for Renewable Energy and Sustainable Technologies
http://www.crest.org

Environmental Defense Fund
http://www.edf.org/issues/globalwarming.html

Environmental Protection Agency
http://www.epa.gov/globalwarming/

Environmental Protection Agency/ Department of Energy Energy Star Program
http://www.energystar.gov

Geoscience Information Center
http://gs.ucsd.edu/news2/

National Geographic Society
http://tectonic.nationalgeographic.com/2000/

National Institute for the Environment
http://www.cnie.org/nle/clim-7/ebgcctop.html

Sierra Club
http://www.toowarm.org

Union of Concerned Scientists
http://www.ucsusa.org/warming/index.html

UN Framework Convention on Climate Change
http://www.unfccc.de/

White House Initiative on Global Climate Change
http://www.whitehouse.gov/Initiatives/Climate/content.html

World Wide Fund for Nature Climate Change Campaign
http://www.panda.org/climate/climate.htm

World Meteorological Organization
http://www.wmo.ch/

World Resources Institute
http://www.wri.org/wri/wr-98-99/kyoto.htm

Source: Michael E. Mann, Raymond S. Bradley, Malcolm K. Hughes

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The Center for Biodiversity and Conservation at the American Museum of Natural History

The study of biodiversity — the immense range and variety of life on the planet — is a long-standing and fundamental activity of the American Museum of Natural History. With its staff of over 200 scientists in ten scientific departments making more than 100 field expeditions each year, the Museum has been at the forefront of efforts to understand the history of life and to discover the myriad species that inhabit the Earth. The Museum's legacy of research and discovery, the concern of its scientists with species loss, and new studies on environmental degradation led to the creation in June 1993 of the interdisciplinary Center for Biodiversity and Conservation.

The Center's work focuses on strengthening scientific research and its relationship to conservation policy and resource management worldwide. By building partnerships across disciplines, institutions, and borders, integrating research with education, and providing the conservation community, decisionmakers, and industry with scientific information, the Center works to preserve biological diversity. We also support the training of international professionals and graduate students, and assist museums here and abroad with outreach programs that teach about the threats to the complex web of life on Earth.

Field programs are under way in Bolivia, Madagascar, Viet Nam, and the New York metropolitan area, and AMNH scientists' conservation projects have taken them to Brazil, the Central African Republic, Cuba, Hispaniola, Gabon, Peru, and Tanzania. The Center has recently established a Remote Sensing and GIS computer laboratory, as well as genetics and marine programs, all devoted exclusively to biodiversity conservation.

Education is an important part of what we do: through symposia, workshops, and publications, we help inform the public about biodiversity issues. To make the complex political and economic decisions necessary for the protection of global biological resources, people must have the scientific tools to identify and understand the mechanisms behind the threats to biodiversity. The Center's role is to equip the world community to use these tools effectively.

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Central Park West at 79th Street, New York, NY 10024-5192
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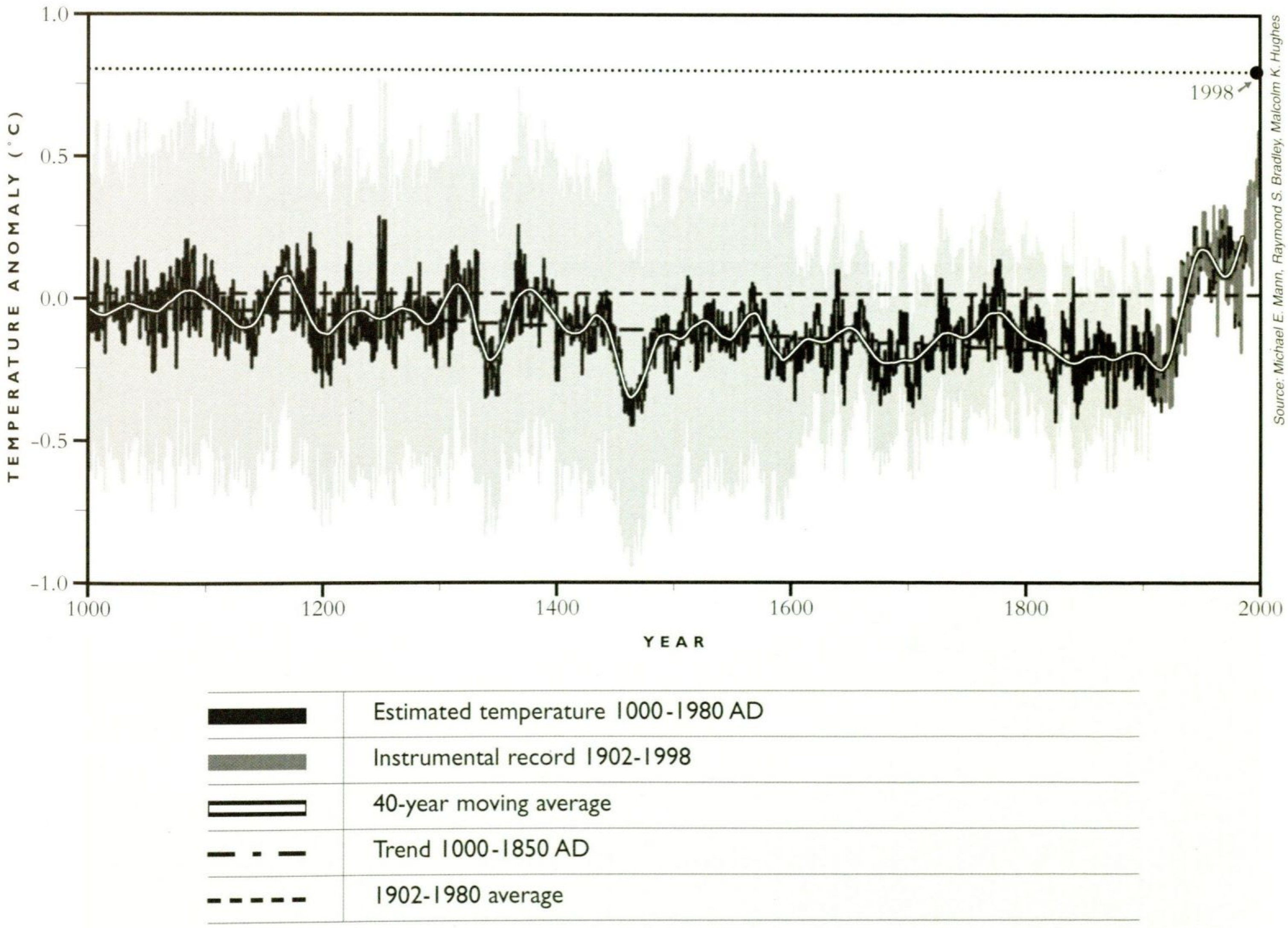
e-mail: biodiversity@amnh.org ■ http://research.amnh.org/biodiversity/

TEMPERATURE CHANGE OVER THE LAST MILLENNIUM

Average temperature in the Northern Hemisphere has increased sharply in the last 100 years, this chart shows. Temperatures from about 1900 come from recorded measurements; earlier temperatures were reconstructed from data found in tree rings, ice cores, sediment cores, and other sources. The margin of error increases the further back in time the reconstruction is taken.



The New York Times

The Gottesman Hall of Planet Earth

American Museum of Natural History
Opening Spring 1999

The Gottesman Hall of Planet Earth – opening in late spring 1999 – is dedicated to exploring how the Earth works, as well as the phenomena and circumstances that make our fragile planet habitable. The Hall addresses five questions asked by Earth scientists: How has the Earth evolved? How do scientists read the rocks? Why are there ocean basins, mountains, and continents? What causes climate and climate change? Why is the Earth habitable?

An array of 167 large, real-life samples, collected from around the world, will present visitors with direct evidence for much of what we know about the Earth's dynamic, 4.5-billion-year history. Exhibits will include a rare ice core from Greenland that contains in its strata evidence of climatic shifts that occurred thousands of years ago, and towering "black smokers," chimney-like sulfide structures that grow at hydrothermal vents in the deep ocean.

A suspended eight-foot hemispherical globe will re-create an awe-inspiring view of Earth – much like what astronauts see from space – allowing visitors to watch the planet's rotation and witness projections of clouds and oceans form and recede across the globe's surface, dramatizing the dynamism of our planet. The Hall will also include an electronic science bulletin – the "Earth Event Wall" – offering continually updated, in-depth explanations of global events such as earthquakes, volcanoes, and major storms as they occur, and reporting on NASA satellite investigations of the Earth.

To find out more about the Gottesman Hall of Planet Earth, please visit the Museum's website at http://www.amnh.org/rose/hope/creatinghope.

Printed on 100% post-consumer fiber processed chlorine free with vegetable-based ink