

Advancing a Systems Approach to Studying the Earth: A Strategy for the National Science Foundation

Committee

Ruth S. DeFries

Co-Chair

Ruth S. DeFries is a professor of ecology and sustainable development at Columbia University in New York. She uses images from satellites and field surveys to examine how the world's demands for food and other resources are changing land use throughout the tropics. Her research quantifies how these land use changes affect climate, biodiversity and other ecosystem services, as well as human development. She has also developed innovative education programs in sustainable development. Dr. DeFries was elected as a member of the U.S. National Academy of Sciences, received a MacArthur "genius" award, and is the recipient of many other honors for her scientific research. In addition to over 100 scientific papers, she is committed to communicating the nuances and complexities of sustainable development to popular audiences through her books "The Big Ratchet: How Humanity Thrives in the Face of Natural Crisis" and "What Would Nature Do?: A Guide for Our Complex World". Dr. DeFries is committed to linking science with policy, for example through her involvement with the Environmental Defense Fund, Science for Nature and People, World Wildlife Fund, and reconciling conservation and development in central India. Dr. DeFries received her Ph.D. in 1980 from the Department of Geography and Environmental Engineering at Johns Hopkins University. She currently serves on the NAS council.

George M. Hornberger

Co-Chair

George M. Hornberger is Distinguished University Professor at Vanderbilt University, where he is the Director of the Vanderbilt Institute for Energy and the Environment. He has a shared appointment as the Craig E. Philip Professor of Engineering and as Professor of Earth and Environmental Sciences there. He previously was a professor at the University of Virginia for many years where he held the Ernest H. Ern Chair of Environmental Sciences. He also has been a visiting scholar at the Australian National University, Lancaster University, Stanford University, the United States Geological Survey (USGS), the University of Colorado, and the University of California at Berkeley. His current work focuses on coupled natural-human systems and aims to understand how climate, groundwater, surface water, energy production, food production, and human abstraction of water interact in complex ways. Hornberger is a fellow of the American Geophysical Union (AGU), a fellow of the Geological Society of America, and a fellow of the Association for Women in Science. Dr. Hornberger won the Robert E. Horton Award (Hydrology Section) from the AGU in 1993. In 1995, he received the John Wesley Powell Award from the USGS. In 1999, he was presented with the Excellence in Geophysical Education Award by the AGU and in 2007 he was selected Virginia Outstanding Scientist. He was elected to the American Academy of Arts and Sciences in 2020. He has served on numerous boards and committees of the National Academies, including as chair of the Commission on Geosciences, Environment, and Resources (1996-2000), chair of the Board on Earth Sciences and Resources (2003-2009), and chair of the Water Science and Technology Board (2013-2017). Dr. Hornberger is a member of the U.S. National Academy of Engineering, having been elected in 1996.

Claudia Benitez-Nelson

Member

Claudia Benitez-Nelson is the Associate Dean for Instruction, Community Engagement, & Research and Carolina Distinguished Professor & Endowed Chair in Marine Studies in the College of Arts & Sciences at the University of South Carolina. As an Associate Dean, Dr. Benitez-Nelson has direct oversight of five departments (Biological Sciences, Mathematics, School of the Earth, Ocean & Environment, Psychology, and Statistics) that encompass over 300 faculty and staff, 300 graduate students, and over 2500 undergraduate majors. Dr. Benitez-Nelson's research focuses on the biogeochemical cycling of phosphorus and carbon and how these elements are influenced by both natural and anthropogenic processes. She is a diverse scientist, with expertise ranging from radiochemistry to harmful algal bloom toxins and is highly regarded for her cross-disciplinary research. Over the past two decades, Dr. Benitez-Nelson has authored or co-authored more than 100 articles, including lead author publications in the journals *Science* and *Nature*. She has been continuously supported by substantial, multi-year research and education grants from the National Science Foundation and the National Aeronautics and Space Administration, among others. Her many research honors include the Early Career Award in Oceanography from AGU and Fulbright and Marie Curie Fellowships. In 2015 she was named an AAAS Fellow, and in 2017, was named an ASLO Sustaining Fellow. Dr. Benitez-Nelson is also highly regarded as a teacher and mentor, having received the National Faculty of the Year Award from the National Society of Collegiate Scholars and the University of South Carolina's Distinguished Professor of the Year Award, SEC Faculty Achievement Award, and Outstanding Faculty Advisor of the Year. In 2014, she received the Sulzman Award for Excellence in Education and Mentoring from the Biogeosciences Section of AGU. Dr. Benitez-Nelson is regularly called upon by national and international scientific and policy agencies for her expertise and currently serves or has served as a member of the Advisory Committee to the Geoscience Directorate of NSF, the EPA Science Advisory Board, and the National Academy of Science's Ocean Studies Board. Dr. Benitez-Nelson earned a B.S. in chemistry and oceanography from the University of Washington and a Ph.D. in oceanography from the Woods Hole Oceanographic Institute/Massachusetts Institute of Technology Joint Program in 1999.

Asmeret Asefaw Berhe

Member

Asmeret Asefaw Berhe is a professor of Soil Biogeochemistry, and Falasco Chair in Earth Sciences at the Department of Life and Environmental Sciences at University of California, Merced. In addition, she serves as the Interim Dean of the Graduate Division at UC Merced; Associate Editor of *Journal of Geophysical Research – Biogeosciences* and *Elementa*. Her research focus lies at the intersection of soil science and global change science. In its most general sense, her research seeks to elucidate how bio-physical and socio-political changes in the environment affect different soil processes and land management. Within this framework, she is exploring two general issues: (a) how geomorphic processes, anthropogenic disturbances, and climate change affect the dynamics of biogeochemical processes (esp. carbon, nitrogen, and phosphorus biogeochemical cycles) in the pedosphere, and its interactions with the atmosphere and hydrosphere on one hand, and (b) how the land use choices that humans make and their relations with land are influenced by complex dynamics between socio-political-economic factors on the other. Her research approaches range from lab- and field-intensive data collection to quantitative analyses and qualitative research methods that attempt to unravel the many facets, causal links, interactions, and feedback mechanisms among different processes in the earth system. In her work, she combines insights from various disciplines. Concepts and methods that she employs in her research are grounded in biogeochemistry, soil science, geomorphology, plant ecology, surface and isotope geochemistry, analytical and atmospheric chemistry, and political ecology. She is the Past Chair and current ex-officio member of the US National Committee on Soil Science at the National Academies; Current member of the Board of International Scientific Organizations; and she is a member of the inaugural class of the US National Academies of Science, Engineering and Medicine's New Voices in Science, Engineering, and Medicine. Asmeret holds a Ph.D. in Biogeochemistry from the University of California, Berkeley, M. Sc. in Resource Development (Political Ecology) from Michigan State University; and B. Sc. in Soil and Water Conservation from University of Asmara, Eritrea. Prior to joining the faculty at UC Merced, Asmeret was a University of California President's Postdoctoral Fellow (2006-2008) at the University of California, Berkeley and at the University of California,

Melissa A. Burt

Member

Melissa A. Burt is the Assistant Dean for Diversity and Inclusion in the Walter Scott, Jr. College of Engineering at Colorado State University. In this position, Dr. Burt, oversees and leads the strategic and implementation efforts for diversity, inclusion, and equity goals across the College. The Office of the Assistant Dean for Diversity and Inclusion focuses on recruitment, retention, and engagement of faculty/staff, and supports the college-wide recruitment and retention efforts of undergraduate and graduate students from historically underrepresented groups. Dr. Burt is also a Research Scientist in the Department of Atmospheric Science at Colorado State University. Her research focuses on the interactions of Arctic clouds, radiation, and sea ice, with interests ranging from cloud-radiation feedbacks, hydrological and energy cycles in climate, and climate change feedbacks. Melissa has a B.S. degree in Meteorology from Millersville University and a M.S. and Ph.D. in Atmospheric Science from Colorado State University.

James J. Elser

Member

James J. Elser is Bierman Professor of Ecology of the University of Montana (UM) and since March 2016 has been Director of UM's Flathead Lake Biological Station at Yellow Bay. He also holds a part-time research faculty position in the School of Life Sciences at Arizona State University. Trained as a limnologist, Dr. Elser is best known for his role in developing and testing the theory of ecological stoichiometry, the study of the balance of energy and multiple chemical elements in ecological systems. Currently, Dr. Elser's research focuses most intensively on Flathead Lake as well as mountain lakes of western Montana and western China. Specific studies involve observational and experimental studies at various scales, including laboratory cultures, short-term field experiments and sustained whole-ecosystem manipulations. Previous field sites have included the Experimental Lakes Area in Ontario, Canada; lakes of the Arctic and of Patagonia; lakes, forests, and grasslands of the upper Midwest; and desert springs in Mexico's Chihuahuan Desert. In recognition of his research accomplishments, in 2019 Dr. Elser was elected to the National Academy of Sciences. He has also been named a Fellow of the American Association for the Advancement of Science (AAAS) as well as a foreign member of the Norwegian Academy of Arts and Sciences. In 2012, Elser received the G.E. Hutchinson Award of the Association for the Sciences of Limnology and Oceanography (ASLO), the world's largest scientific association dedicated to aquatic sciences.

Courtney G. Flint

Member

Courtney G. Flint is a Professor of Natural Resource Sociology at Utah State University. Her work focuses on the perspectives and collective actions of people in changing landscapes and social and natural resource conditions. She strives to provide sound data to support local and regional decisions on land use, natural resource management, and wellbeing. Her research is highly interdisciplinary as she has worked closely with researchers from water science, engineering, forestry, biogeochemistry, plant phytochemistry, agricultural science and engineering, systems ecology, landscape planning, and other sciences as well as local leaders and representatives of citizen action groups to address complex social-environmental changes.

Her current research and engagement efforts emphasize inquiry and assessments related to individual and community wellbeing, as well as the social ecology of rivers in the US Intermountain West. She serves on the Board of Scientific Counselors for the U.S. Environmental Protection Agency as the chair of the subcommittee on Sustainable and Healthy Communities as well as on other advisory boards in Austria and South Africa.

Her bachelor's degree is in geography from Northern Arizona University, her master's degree is in geography from the University of Colorado at Boulder, and her PhD is in rural sociology from Penn State University where she also enjoyed a strong working relationship with the US Forest Service's Pacific Northwest Research Station that extended into her post-doctoral research and tenure track position at the University of Illinois at Urbana-Champaign. She moved to Utah State University in 2013 where she is now a Professor of Sociology and a Community Resource Specialist for USU Extension. She directs the Institute of Social Science Research on Natural Resources and serves on the leadership team for the NSF-funded Climate Adaptation Science Graduate Training Program at USU.

Royce A. Francis

Member

Royce A. Francis is an associate professor in the Department of Engineering Management and Systems Engineering at George Washington University. His overall research vision is to conduct research, teaching, and service that facilitates sustainable habitation of the built environment. This vision involves three thrusts: 1.) infrastructure management, including sustainability assessment and risk analysis; 2.) regulatory risk assessment and policy-focused research, especially for environmental contaminants and infrastructure systems; and, 3.) statistical/mathematical modeling approaches to decision support. He unifies these multi-disciplinary interests under the Earth Systems Engineering and Management (ESEM) paradigm for civil/environmental systems design and analysis. In the past year, Dr. Francis's research program has incorporated two new thrusts: i.) Investigating macrocognitive decision making processes for infrastructure resilience; and ii.) Characterizing engineer identity and engineering judgment situated in low-cost air quality sensor network design. Dr. Francis earned the Ph.D. from Engineering and Public Policy and Civil and Environmental Engineering at Carnegie Mellon University, M.S. in Civil and Environmental Engineering from Carnegie Mellon University, and the B.S. in Civil Engineering from Howard University.

Inez Y. Fung

Member

Inez Y. Fung is a Professor of Atmospheric Science in the Department of Earth and Planetary Science and the Department of Environmental Science, Policy and Management at the University of California, Berkeley. She studies climate change and the carbon cycle using global-scale numerical models of the Earth System and its components. Fung received her S.B. in Applied Mathematics (1971) and her Sc.D. in Meteorology (1977) from MIT. Among her numerous honors are membership of the US National Academy of Sciences, the Royal Society, London, and Academia Sinica (Taiwan). She was the US lead for the 2014 joint NAS-Royal Society study "Climate Change: Evidence and Causes" and its 2020 update. Fung is a subject in a biography series for middle-school-aged readers, "Women's Adventures in Science", launched by the National Academy of Sciences. The title of her biography is "Forecast Earth". She was also featured in a short YouTube video sponsored by WIRED magazine: "What could happen in a world that's 4 degrees warmer?".

William D. Gropp

Member

William "Bill" D. Gropp is Director of the National Center for Supercomputing Applications and holds the Thomas M. Siebel Chair in the Department of Computer Science at the University of Illinois at Urbana-Champaign. His research interests are in parallel and high performance computing, software for scientific computing, and numerical methods for partial differential equations. He has played a major role in the development of the MPI message-passing standard. He is co-author of one of the most widely used implementation of MPI, MPICH, and was involved in the MPI Forum as a chapter author for both MPI-1 and MPI-2. He has written many books and papers on MPI including "Using MPI" and "Using MPI-2." He is also one of the designers of the PETSc parallel numerical library and has developed efficient and scalable parallel algorithms for the solution of linear and nonlinear equations. Gropp is a Fellow of AAAS, ACM, IEEE, and SIAM and received the Sidney Fernbach Award from the IEEE Computer Society in 2008. In 2016, the Association for Computing Machinery (ACM) and IEEE Computer Society named Gropp, a professor of computer science at the University of Illinois at Urbana-Champaign the recipient of the 2016 ACM/IEEE Computer Society Ken Kennedy Award for highly influential contributions to the programmability of high-performance parallel and distributed computers. Gropp is a member of the National Academy of Engineering. William Gropp received his B.S. in Mathematics from Case Western Reserve University in 1977, an MS in Physics from the University of Washington in 1978, and a Ph.D. in Computer Science from Stanford in 1982. Gropp has served on several panels and a study for the National Academies, including the Panel on Digitization and Communications Science (2008--2010), the Study Committee (co-chair): Future Directions for NSF Advanced Computing Infrastructure to support US Science in 2017-2020 (2013-2015), the Panel on Computational Sciences at the Army Research Laboratory (2017), and the Panel on Review of Extramural Basic Research at the Army Research Laboratory (2018-2019).

Melissa A. Kenney

Member

Melissa A. Kenney is the Associate Director of Knowledge Initiatives at the University of Minnesota's Institute on the Environment (IonE) where she directs efforts to build synergy across IonE's broad scientific research portfolio. To achieve this goal, she collaborates with faculty, community partners, the University of Minnesota's systemwide campuses, and the IonE management team to sustain existing and launch new research efforts in support of the strategic plan. Dr. Kenney is an environmental decision scientist with expertise in multidisciplinary, team-based science approaches to solving sustainability and Earth system challenges. Her research program broadly addresses how to integrate both scientific knowledge and societal values into policy decision-making under uncertainty. Her research expertise includes conceptual modeling and decision structuring, indicators, systems analysis, multi-attribute methods, and evaluation of decision support to address environmental policy decisions. These decision support tool and collaborative decision-making processes methods have been applied to a range of topics including participatory global change indicators, setting environmental policy criteria, economic analyses for restoration alternatives assessment, expert elicitation, value of information of indicators, and improving ecological forecasts. Over the past decade, this work has led to more than 50 publications; over \$5M in grants awarded; more than 100 invited talks; multiple invited White House events integrating her research findings; and opportunities to translate scientific findings as policy memos or decision support prototypes to federal agencies and the highest levels of government. She was an invited presenter to the National Academies of Science, Engineering, and Medicine (NASEM) Roundtable on Science and Technology for Sustainability on Measuring Progress toward Sustainability and an invited roundtable participant for the Measures of Community Resilience workshop as part of the Resilient America Program. In addition to Dr. Kenney's multidisciplinary scientific research, she has extensive experience in high-level science policy coordination and relationship building between Federal and academic institutions. In her former role as an AAAS Science and Technology Policy Fellow, she played a role in visioning a transboundary climate early warning system in the Columbia River basin, facilitated academic center collaborations via an NOAA and NSF partnership, advised several federal agencies on enhancing their social science research agendas, and recommended methods to quantify the value of Federal programs. In recognition of her public engagement leadership, she was part of the inaugural cohort of AAAS Leshner Leadership Institute Public Engagement Fellows, where she focused on enhancing stakeholder-engaged research to create climate-resilient solutions in the U.S. and Chesapeake Bay region. Previously, Dr. Kenney was an Associate Research Professor in Environmental Decision Science at the University of Maryland and research faculty in the Department of Geography and Environmental Engineering at Johns Hopkins University. She was a postdoctoral scholar with the National Center for Earth-surface Dynamics at the University of Minnesota and Johns Hopkins University. She received a B.A. with Distinction in environmental sciences from the University of Virginia in 2002, and she earned a Ph.D. from Duke University in 2007, focused on integrating water quality and decision models.

Jerry X. Mitrovica

Member

Jerry X. Mitrovica is the Frank B. Baird, Jr., Professor of Science at Harvard University. His work focuses on the Earth's response to processes that have time scales ranging from seconds to billions of years. He has written extensively on topics ranging from the connection of mantle convective flow to the geological record, the rotational stability of the Earth and other terrestrial planets, ice age dynamics, and the geodetic and geophysical signatures of ice sheet melting in our progressively warming world. Sea-level change has served as the major, unifying theme of these studies, with a particular emphasis on critical events in ice age climate and on the sea-level fingerprints of modern polar ice sheet collapse. Dr. Mitrovica is a former Director of the Earth Systems Evolution Program of the Canadian Institute for Advanced Research and J. Tuzo Wilson Professor in the Department of Physics at the University of Toronto. He is the recipient of the Arthur L. Day Medal from the Geological Society of America, the W.S. Jardetsky Medal from Columbia University, the A.E.H. Love Medal from the European Geosciences Union and the Rutherford Memorial Medal from the Royal Society of Canada. He was recently named (2019) a Fellow of the MacArthur Foundation. He is also a Fellow of American Geophysical Union and the Geological Society of America, as well as a past Fellow of the John Simon Guggenheim Memorial Foundation.

Constantine Samaras

Member

Constantine (Costa) Samaras is an associate professor at Carnegie Mellon University in the Department of Civil and Environmental Engineering. Dr. Samaras's research spans energy, climate change, automation, and defense analysis, and he directs the Center for Engineering and Resilience for Climate Adaptation. He assesses how technology, policy, and infrastructure system designs affect energy use, system resilience to climate change impacts, economic and equity outcomes, and life cycle environmental emissions and other externalities under uncertainty. He currently serves as the Chair of the ASCE Committee on Adaptation to a Changing Climate. Dr. Samaras is also an adjunct senior researcher at the RAND Corporation. From 2009 to 2014, he was a researcher at the RAND Corporation, and from 1999-2004 was a megaprojects engineer in New York. Dr. Samaras received his Ph.D. in civil and environmental engineering and engineering and public policy from Carnegie Mellon University in 2008, and earlier received a MPA from New York University and a BS from Bucknell University. He has previously served on the National Academies Review of the U.S. DRIVE Research Program-Phase 4 Committee, and on the Committee on Enhancing Air Mobility--A National Blueprint.

Kristen St. John

Member

Kristen St. John is a Professor of Geology at James Madison University. She earned her B.S. in Geology at Furman University (1992), and her M.S. (1995) and a Ph.D. (1998) in Geological Sciences from The Ohio State University. Her research extends across two areas: (1) undergraduate geoscience curriculum design and community development and (2) marine sedimentology/paleoceanography. She was the Editor-in-Chief of the Journal of Geoscience Education from 2012-2017. She delivered the presentation on the future of geoscience education research in the 2019 AGU Centennial Plenary: Inspire the Future for the Benefit of Humanity. She was the lead researcher and editor of the vision and planning report: A Community Framework for Geoscience Education Research. An active researcher in the International Ocean Discovery Program (IODP), she was a marine sedimentologist for several expeditions, and worked on samples from the Arctic, North Atlantic, and North Pacific to investigate the marine record of iceberg and sea ice changes through time. She is the co-chief scientist for the future Arctic Ocean Paleoceanography expedition (Arc-OP, IODP Exp. 377). Her work in scientific ocean drilling and education intersect in two books projects; she is the lead author on Reconstructing Earth's Climate History: Inquiry Exercises for Lab and Class, and is collaboratively preparing a new introductory textbook, Climate Change: A Geosciences Perspective. She served on the U.S. Steering Committee for Scientific Ocean Drilling, was a co-leader of the IODP NEXT workshop and the IODP workshop on Scientific Exploration of the Arctic and North Pacific. Currently, she is on the U.S. IODP Education and Outreach Committee and the National Academies of Science Polar Research Board. At JMU, she received the General Education Distinguished Teacher Award in 2013, the College of Science and Math Outstanding Teaching Award in 2014, the Research and Scholarship Lifetime Achievement Award in 2017, and the Roberts Endowment for Faculty Excellence Award in 2019. She was recognized as Geological Society of America (GSA) Fellow in 2016.

Fiamma Straneo

Member

Fiamma Straneo is a Professor in Polar Climate and Oceans at the Scripps Institution of Oceanography of the University of California San Diego. Prior to joining Scripps, she was a Senior Scientist at the Woods Hole Oceanographic Institution until 2017. She studies the high latitude North Atlantic and Arctic Oceans and their interaction with the atmosphere, sea-ice and the Greenland Ice Sheet. Much of her research has focused on obtaining and interpreting data from the challenging regions at the glaciers' margins. Straneo has led over a dozen field expeditions to the Arctic and Greenland. She has collaborated extensively with glaciologists and ice sheet modelers, and recently chaired the Ocean Forcing Working Group for the Ice Sheet Modeling Intercomparison Project. Straneo is co-chair of the Climate and Cryosphere Program of the World Climate Research Program, co-chair and founder of the Greenland Ice Sheet/Ocean Science Network (GRISO), a member of the Atlantic Meridional Overturning Circulation Science Team and of the ASOF (Arctic-Subarctic Ocean Fluxes). She is also a fellow of the Leopold Leadership Program and was awarded the Sverdrup Lecture by the Ocean Sciences Section of the American Geophysical Union in 2016. Straneo obtained her Ph.D. in Physical Oceanography in 1999 from the University of Washington, USA, following a Laurea cum Laude in Physics in 1993 from the University of Milan, Italy.

Duane E. Waliser

Member

Duane E. Waliser is Chief Scientist of the Earth Science and Technology Directorate at the Jet Propulsion Laboratory (JPL) in Pasadena, California, which formulates, develops, and operates of a wide range of Earth science remote sensing instruments for NASA's airborne and satellite program. His principal research interests lie in Earth system processes, observations and modeling; weather-climate linkages, particularly subseasonal to seasonal (S2S) variability; prediction and predictability; and the Earth's water cycle. His recent foci at JPL involves working within NASA and across agencies to enable and enhance societal benefits from our growing understanding, observing and modeling capabilities of the Earth System. He received a B.S. in physics and a B.S. in computer science from Oregon State University in 1985, an M.S. in physics from UC San Diego in 1987, and his Ph.D. in physical oceanography from the Scripps Institution of Oceanography at UC San Diego in 1992. Past interactions with the Academies include membership in the following three studies: 2010 Assessment of Intraseasonal to Interannual Climate Prediction and Predictability, 2016 Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts, and 2018 Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space, as well as current membership on the on the Board on Atmospheric Science and Climate and the Committee on Earth Science and Applications from Space.

Lauren Everett

Staff Officer